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MAJOR GENERAL of the ARTILLERY

V. G. DYAKONOV

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COURSE OF ARTILLERY

BOOK 9.

OBSERVED SHOOTING.

Edited by

MAJOR GENERAL OF ENGINEER-ARTILLERY SERVICES

A. D. BLINOV

The Military Publishing House

of the

Ministry of the Armed Forces

of the

USS.S.R.

MOSCOW - 1949.

On the reverse

Major General, Professor, Doctor of Military Sciences [illegible] Dyakonov, Course of Artillery, Book 9, Observed Shooting.

The book deals with ground burst ranging, fire for effect, firing under special conditions and firing with shells of a special character.

This book is recommended by the Directorate of the Artillery Military-Scientific Organizations as a text book for students of artillery schools. In addition it may serve as an aid to private study for officers of the Soviet Army.

CONFIDENTIAL

INTRODUCTION.

p.3 The ninth, tenth and eleventh books of the Artillery Course deal with the firing of a gun, a troop and a battery.

In the scientific development of these problems, an honoured place belongs to Russians and particularly to Soviet artillerymen.

As far back as the nineteenth century Russian scientist-artillerymen Zabudski and Mayevski worked out in detail the problems of external ballistics. On the basis of this work the rules of artillery fire were first laid down, scientifically based on the theory of probability and the theory of error. By that time both these sciences had reached a high level of development thanks to the work of Russian mathematicians: Chebyshev and Markov.

Prior to the Russo-Japanese war field artillery fired exclusively from open positions. During the Russo-Japanese war the greater part of artillery began taking up covered positions.

Russian artillery officers Paschenko, Gobyato, Belyayev, Shikhlinski and others first developed the rules for preparing data in conjunction with the use of the theodolite (director) and the rules for firing from closed positions, using the coefficient of range and the director.

Although Russian artillery was in a leading position even in the first world war, Russian artillerymen nevertheless had not had time to work out a number of very important problems connected with the firing of modern artillery.

Soviet land artillery inherited from the old army the Rules fir Firing published in 1917; which were a copy of the Rules for Firing of 1911. These were in point of fact merely rules for ranging by observation. It is true, these rules were worked out and based theoretically on most exhaustively worked out detail.

However, the wealth of experience accumulated by Russian artillerymen during the first world war was not reflected in the Rules for Firing of 1917 and the task of drawing up a balance sheet and of extracting deductions from the experiences of the first world war fell to the Soviet Artillerymen.

Amongst the problems which required the most urgent attention was in the first place the matter of firing without ranging or with
p.4 limited ranging. The rapid growth during the first world war in the strength of artillery and the resultant heavy distribution of artillery to formations required the development of methods of firing which allowed firing without each troop having to range on all the targets allotted. To these methods must be linked the full artillery prepation on the [illegible] ~~[illegible]~~, the switch of fire from land and air bursts and the employment of ranging guns.

In the Rules for Firing 1917, there were likewise no instructions on firing at invisible targets and in particular counter battery fire. At the same time an advance even then could not succeed without the neutralization of enemy batteries, without striking at reserves not visible from the ground and without seriously disrupting the work of the enemy's staff and rear services.

The method of striking other targets was then not yet worked out; in the Rules for Firing 1917, no mention is made either of the order of fire or of the rate of expenditure of ammunition when firing at one or another type of target.

Already in the course of the first world war wide use was made of special types of shell: smoke, incendiary, illuminating. But the rules for firing these shell had not been worked out.

No rules existed for OT shooting, firing in mountainous terrain, ranging by measured deflections etc.,

All the directions contained in the Rules for Firing 1917, dealt with troops and firing by batteries and higher formations was not touched upon.

This by no means exhausted list of important problems of firing that had not been worked out by the end of the first world war shows the magnitude of the task facing Soviet artillerymen. In fact it was necessary to tackle afresh all questions relating to the preparation for and the control of fire in the conditions of modern warfare.

Those engaged in work on these problems were in the first instance the Artillery Firing and Tactical Committee, the Artillery Academy and the Senior School for Artillery Officers. But the development of the methods of firing was not limited to the narrow circle of specialists working in the above mentioned scientific artillery centres - the most active part in the development of the theory of fire and in the experimental work was played by many regimental artillery officers. They put forward their theories through the pages of military journals and sent their ideas to the The Firing tactical Committee. A considerable number of these suggestions were of very great value: In them were brought forward completely new and original methods of preparation of original gun data, of ranging and firing for effect and many improvements to previously worked out methods.

p.5. With regard to some of the methods of preparing gun data and of firing it is difficult to find the author: an idea submitted by one officer was immediately seized upon by many others, who by their contributions markedly improved the method suggested in the first instance. The result of such fruitful collective effort and the determined endeavours of many enthusiasts of the art of artillery, the suggested method finally crystalized itself, took shape in the most practical form, was accepted into Soviet artillery practice and was included in the current edition of Rules for Firing.

The Soviet Army worked out, theoretically established and checked by many experiments and finally entered up in the Rules for Firing many methods of ranging by measured deflections, the switching of fire from a map, bringing effective fire down on invisible targets and in particular the neutralization and destruction of enemy batteries, rules for anti tank fire, close support of infantry and tanks in the attack, rules for firing in mountainous terrain, shooting with a large displacement angle and rules for firing with limited and full preparation of basic gun data.

During the same period much experimental work was done: the rate of fire of guns was investigated, the fragmentation action of shells, the most advantageous grouping of shells in a given area and many other matters were dealt with.

As the science of artillery fire developed so the Rules for Firing were published. The additions of 1924, 31, 34 and 39 reflected the continuous improvement in the Soviet artillery methods of firing; during the same period new text books were compiled on artillery firing.

By the beginning of the Great Fatherland War the Soviet army possessed artillery which held first place amongst the armies of the whole world, in the sphere of the scientific development of artillery fire.

Soviet artillery possessed fully up to date, scientifically based Rules for Firing, the majority of these having been put to the test experimentally on the ranges.

The artillery of the Soviet army, thanks to the exceptional efforts of Comrade Stalin, was by this time equipped with the most modern types of weapons and instruments.

Guided by the directions of Comrade Stalin, the oldest Soviet artillerymen, managed to train a large number of young officers who mastered, to a very high degree, the art of artillery fire.

In the course of the Great Fatherland War the scientific correctness and the practical feasibility of all the principles of the Rules for Firing were checked and confirmed; the war likewise confirmed the superiority of our artillery armament over the armament of the
p.6 enemy. The war also proved that Soviet artillerymen possess vast knowledge and have a greater mastery of the art of firing as compared with the army of our enemy.

As a result, Soviet artillery passed with honours the greatest tests set by the war and fully justified Comrade Stalin's definition: "Artillery is the main striking force of the Red Army".

In the course of the war, Soviet artillerymen continued to perfect the previously created methods of firing and at the same time worked to produce new ones. The basic factors which determined the direction of development of the methods of artillery fire during the Great Fatherland War were:

1) the use by the enemy of large numbers of tanks with an increase, as compared with pre-war, of thickness of armour, greater speed

and new type of armament;

2) the great overall increase in the numbers of our artillery and the increase in the distribution of artillery to other formations, particularly in break-through sectors;

3) the unprecedented size and scope of advancing operations and the speed of advance of our troops in the move forward.

The great achievements of our artillery as compared with the artillery of other armies taking part in the war was the fact that thanks to our correct approach to the problems of firing on tanks a great deal of thought was given to this matter before the war. War did not catch the Soviet artilleryman unprepared and German tanks suffered enormous, irreplaceable losses as a result of our artillery's accurate fire.

The very heavy concentration of artillery on a break-through sector (200 and more guns to a kilometer of front), the wide front and the depth of advance linked with high speed of movement forced a revision to be made in the existing methods of directing fire.

To achieve operational and tactical surprise it was necessary to cut down considerably the length of artillery preparation as compared with the first world war.

Under these conditions of warfare the Soviet artillerymen were faced with the following problems:

detailed development and practical application of methods of preparation which allow the simultaneous direction of fire from a large number of guns, either without ranging or with a shortened form of ranging;

the development of the technique of directing the fire of large artillery concentrations, taking into account the necessity to be able to concentrate the fire of several batteries and sometimes of several regiments on to one target;

the development and application of speeded up methods of preparation for the opening of directed fire effectively against targets deep within the enemy's defence immediately after a break through of the enemy's forward positions;

p.7 the development and application of methods of close support for tanks and infantry.

Soviet artillerymen skilfully solved all these problems.

The spectacular success of most offensives was to a large extent guaranteed by the effective directed massed fire of Soviet artillery, a fact frequently underlined in the orders of the day of the Commander in Chief, Comrade Stalin.

The vast experience gained during the Great Fatherland War in the realms of artillery firing was reflected in the "Rules for Firing 1942 and to a much greater extent in the Rules for Firing 1945. But during the short period of time which has elapsed since the end of the Great Fatherland War the problem of studying the wealth of experience relating to questions of artillery fire could be only be solved in part.

Soviet artillerymen continue to labour towards their goal of extracting value from the experiences of war and on a basis of analysis of results, making use of the latest scientific developments to perfect skill further the methods of firing and to apply them skilfully in their practical work.

Chapter 1.

RANGING BY OBSERVATION OF FIRE.

p.8. 1. The Task and General Plan of Ranging.

The preparation of the initial setting which precedes all forms of firing is always subject to error which cannot be fully eliminated but may only be lessened by the employment of more accurate/of preparation. As a result firing on settings attained through the prepatation does not guarantee the coincidence/the mean point of impact with the target or even its proximity to it, and therefore does not guarantee the destruction of the target. The most advantageous setting for the destruction of the target is determined during the process of shooting. This phase of shooting is called ranging.

/method

/of

The object of ranging is therefore the determination of the error in the working out of the initial setting and the introduction on this basis of corrections, which guarantee the destruction of the target.

If the observer could measure the correction needed for line then the determining of the correction necessary to bring the mean point of impact to coincide with the target would not present any very great difficulty, and the problem of ranging would be solved comparatively simply. In practice under certain conditions, such a method of ranging is employed (see Book 10, Course of Artillery, "Ranging by measured deflection").

However, the employment of this method is not always possible as the measurement of the lateral error requires a corresponding organization of fire and the availability of definite recce and observation resources. Therefore, in cases where the situation (time, available observation and communication resources etc.,) does not allow for the measurement of the lateral error, another method of ranging is employed, by observing the bursts. Employing this type of ranging, the observer measures from his position the lateral deviation of the burst from the line of observation, and only determines the sign of error in range, without measuring its size, i.e., determines whether the burst has occurred on this side or on the far side of the target, (plus or minus). Having made his
p.9. observation for range (plus or minus) the observer makes a correction for range for the next [illegible] rounds, gradually bringing the bursts closer to the target. The process of bring the bursts closer to the target is accomplished by means of bracketting the target, i.e., the discovering of such settings on the sights whereby one results in a minus and the other in a plus, and of further halving of the achieved bracket. In this case it is possible to determine the position of the burst from the point of view of range, that is to determine plus or minus, generally speaking only if the bursts are along the line of observation, i.e., the line observer - target.

Therefore, ranging for range is as a rule carried out simultaneously with ranging for line.

If there were no dispersal of the rounds or if the zone of the gun were so small that the dispersal could be ignored, then the narrowing of the bracket would be limited exclusively by the accuracy of the sighting mechanism and the subsequent halving of the bracket would bring the mean point of impact to the target. The existence of dispersal of rounds introduces material alterations into the plan of ranging, as with the approach of the mean point of impact to the target, there develops the probability of getting plusses at a minus range and minuses at a plus range.

Fig 1. caption. Getting bracket $h_1(-)$ and $h_2(+)$

As an example in fig 1 it is shown that both mean points of impact, one corresponding to the setting h_1 and the other to the setting h_2 are minus in relation to the target.

If the round fired with the setting h_1 busts on the point P_1 and the round fired with the setting h_2 bursts on the point P_2 (within the limits of dispersal) then the observer on the basis of the observations (minus with setting h_1 and plus with setting h_2) will consider the bracket as having been achieved and for further shooting will give the setting h_2. Thus owing to the influence of the dispersal of rounds , the subsequent course of ranging will be such as to render possible the ordering of wrong settings for fire for effect.

To lessen this possibility the limits of the brackets are confirmed, i.e., rounds are repeated on the settings by which the bracket was obtained.

We thus have the following system of ranging by observation. The first round is fired with sight settings determined as a result of preparation of basic data. Having obtained observation for range,
p.10. the setting of the sight is altered (and if necessary of the dial sight) with the object of bracketting the target. It is obvious that the width of the first bracket will depend on the accuracy of the initial calculation. The more accurate the initial calculations are, the less likely is there to be an error in range and consequently the first bracket will be smaller.

The bracket so obtained must be halved several times. It is perfectly obvious that the size of the last bracket will depend on the dispersal of rounds. The greater the dispersal, the greater will be the size of the last bracket. The last bracket obtained is verified, i.e., the rounds forming the bracket are repeated until two identical results are obtained at either end of the bracket, this is followed by fire for effect.

In the above plan of ranging, it is necessary to give theoretical proof of the following points:

a) ranging for line; the getting and keeping of the bursts on the line of observation;
b) width of the first bracket under various methods of data preparation;
c) reducing the bracket; determine how many times it is necessary to halve the bracket and what must be the size of the last bracket;
d) the confirmation of the extremities of the bracket; to determine which bracket is to be confirmed and how many signs there must be on each extremity;
e) choice of the sight setting for going over to fire for effect after obtaining a bracket or a contradiction (i.e. plusses and minuses at the same sight setting).

Ranging by observation does not require any very special organization or preparation for fire; neither does it require any special means for observation. For this reason it may be employed under any battle conditions and is therefore the basic means of ranging for all forms of artillery and for regimental artillery is the only means of ranging on observable targets. At the same time, ranging by observation requires of the observer considerable experience, skill, and what is particularly important, the ability to observe, i.e., the ability to distinguish between plusses and minuses often by means of hardly perceptible indications. Ranging requires reliable and uninterrupted observation. All doubtful observations must be disregarded when evaluating range. The smoke of the burst must be observed at the moment of its appearance. To follow the smoke of the burst is of some purpose in the event of there being a cross wind in relation to the line of observation, when the smoke may cross in front of the target or behind it and give an indication.

When ranging the same type of round is used with the same charge as will be used in the fire for effect. The fuze used in ranging and in fire for effect must be of the same type and in both cases either with or without cap. The charges and if possible the rounds in ranging and firing for effect must be from the same batch (with the same markings).

p.11 2. <u>Ranging for Line</u>.

Ranging for line, which is carried out simultaneously with ranging for range, consists of:

a) correcting the [redacted] direction of the ranging gun;
b) concentration of remaining guns.

In correcting the ranging gun for line, the deflection of the burst from the line of observation is measured in the divisions of the dial sight and the troop (gun) is ordered to turn the sights in the opposite direction, to the amount of the determined deflection, multiplied if necessary by the coefficient of range. Correcting for line is carried out until the bursts are brought on to the line of observation or sufficiently close to it to permit of observation of the signs for range. In all subsequent alterations of the sight settings for range, the setting of the dial sight is altered in the corresponding direction by one unit, with the object of keeping the bursts on the line of observation.

In altering the dial sight the lateral deflection of the preceding rounds is taken into account at the same time.

Large lateral deflections from the target are as a rule measured with less accuracy than small deviations. This is first of all explained by the fact that in the case of a large lateral deflection from the line of observation the burst may not be within the field of vision of the aid to observation. As a result the burst will be observed late and during that time the smoke of the burst may be carried away by the wind and the measurement of the deflection will be made not from the point where the burst occurred. In addition the measuring of large deflections by means of such apparatus as field glasses is done with relatively small accuracy because it is necessary to measure in turn several angles between intermediate points on the ground and this introduces fresh errors. Finally multiplying the measured deflection by the coefficient of distance calculated always on a nearer point, an error is introduced, the greater the deflection, the greater the error.

The rules for correcting for line arrived, taking into account the relative accuracy of the measurement of the lateral deflections depending on their size, are as follows.

The correction for line of more than 0.20 it is permissible for the sake of simplicity to express in round figures: up to five divisions of the dial sight in the case of a correction not exceeding
/ten 1.00 and up to/[redacted] divisions of the dial sight in the case of a correction of over 1.00.

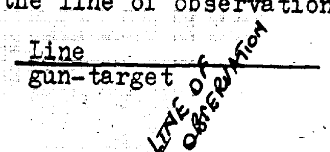
Correction for line of less than 0.20 is made to an accuracy of one division of the dial sight.

In correcting for line the deflection of an isolated burst is taken as the deflection of the mean point of burst, the position of which in actual fact does not correspond with the position of that burst. As a result of this an error appears which is the result of the dispersal of rounds and the angle error of measurement.

p.12. The mean angle error of the measurement of deflection of bursts depends on the conditions for observation, the size of the burst, the degree of training of the observer, the size of the deflection itself and the type of apparatus which is used for measuring. Under moderate conditions, (and not very great deflections of bursts from the target) this error may be taken as being one to two divisions of the dial sight when measuring the deflection with "donkey's ears" and two to three divisions of the dial sight when measuring by means of binoculars.

The error due to dispersal of the rounds varies according to the displacement of the observation post. In the case of observation
/of along the line/[redacted] fire the length of the 100% zone does not affect the determing of the lateral deflection from the line of observation of the mean point of impact. In this case only the lateral deflection is of importance, characterized by the size of Vb ($B\delta$), which for our guns is from one half to one division of the dial sight. In the case of the OP not being on the line gun - target, the mean lateral deflection from the line of observation (fig 2) will be considerably greater than Vb ($B\delta$).

Fig.2. caption. Determing the size of the mean lateral deflection from the line of observation.



From the theory of errors it is known that the square of deflection d is equal to the sum of the squares of the projections in this direction of Vd ($B\partial$) and Vb($B\delta$) i.e.

$$d^2 = B\partial^2\cos^2(90^\circ-\alpha)+B\delta^2\cos^2\alpha$$

where α is the angle formed by the line OP-target with line gun-target.

Consequently,

$$d = \sqrt{B\partial^2 \sin^2\alpha + B6^2 \cos^2\alpha}.$$

In the event of the OP being on the line gun - target, that is if the line of observation coincides with the line of target, then the angle α = zero and consequently $d = B6$.

Let us work out by the formula above the extent of d for the various positions of the observer, taking the angles α to be equal to: 0, 1,00, 2,00, 3.00, 5.00, and 7.00. Let us take the range as being equal to 4 kilometers and corresponding to this range $B\partial$ equals 20 m and $B6$ equals 2 m.

The results of the calculations are given in the table below. (table 1).

p.13.

Table 1.

Angle of observation.	0	1.00	2.00	3.00	5.00	7.00.
Mean deflection in m.	2	2.9	4.6	6.5	10.1	13.5

We therefore see that the accuracy of corrections for line depends also on the angle of observation i.e., on the angle of displacement. The greater the displacement, the more the dispersal of the rounds has effect. In the case of the OP being close to the line gun target the correction error due to displacement will be small and the basic error is the error in measuring the deflection itself. As shown above, the mean error of measuring the angle of deflection by means of binoculars is equal to two to three divisions on the dial sight. In the case of considerable displacement, it is necessary to take into account the error due to the dispersal of rounds.

On this basis the following rules for corrections for line are given: in firing on narrow targets with the OP close to the line gun - target the correction of less than .03 and in the case of displacement, less than .05 are introduced after obtaining not less than two observations. In firing on wide targets minor corrections should not be introduced as in the case of small deflections the bursts will not fall outside the target area; the introduction of minor corrections will only result in excessive loss of time.

When ranging troops, in addition to correcting the ranging gun for line it is also necessary to concentrate the remaining guns.

There are the following types of concentrations:

a) concentrated, when all the guns are directed at one point; the practical width of the fan must not exceed eight $B6$ of one gun.

b) Effective concentration, when the distance between the bursts is roughly equal to the width of the effectiveness of burst of individual rounds.

In firing with a fragmentation fuze or with ricochets, likewise with HE shell, the distances between bursts must be roughly equal.

For shells of 76mm calibre and 82mm mortar... ... ... 30 m
" " "107mm " " 107mm " ... ... 40 m
" " "122mm " " 120mm " ... ... 50 m
" " "152mm " " ... ... 60 m

c) Contracted, according to width of target, when the width of the fan (and consequently the width of the target) is less than the width of the fan for effective concentration.

d) Distribution of fire, of individual guns on to various points of the target.

p.14. Concentration consists of giving the fan a width corresponding to the width and the nature of the target and is carried out on the basis of measuring lateral deflections of bursts.

If the displacement is less than 0.3 then the concentration of the fan is carried out as a rule by means of concentration or distribution of fire or by correcting every gun for line.

Example 1.

Fire is carried out by a 122 mm howitzer troop with shells with fragmentation fuzes; $Д\kappa$ = 2km; $ДБ$ = 5 km; with a correct direction given to the ranging (right) gun, the distances between bursts measured from the OP were as follows:

between the first and second bursts - 0.10;
between the second and third bursts - 0.08;
between the third and fourth bursts - 0.11.

It is necessary to concentrate the guns to "effective concentration".

Since $Ky = \frac{\Delta K}{\Delta S} = 0.4$, then the intervals between bursts for the gun position, as shown by the divisions on the dial sight, will be equal to right - 0.04, middle - 0.03 and left - 0.04.

The intervals between bursts in the spread of an "effective concentration" must be equal to 50 meters, which with a range ΔS =5km will be 0.10.

For the simplification of the re-arrangement of the spread, the intervals arrived at may be taken as being equal, being 0.04.

Consequently to obtain the spread for an "effective concentration" the order is given: "Divide the fire from the right, 0.06".

Example 2.

ΔK = 2,400 meters, ΔS = 4,000 meters. The frontal dimension of the target and deflection of bursts from the right hand edge, measured from the OP are given in fig 3. It is necessary re-arrange the pattern of the spread according to the width of the target.

To re-arrange the pattern of the spread by bringing together or by dividing the fire is not possible in this instance as the pattern is crossed with unequal intervals between bursts.

Fig 3. The position of the spread of bursts in relation to the target
Note: in diagram P stands for burst.

It is necessary to correct each gun for line. Since $Ky = \frac{\Delta K}{\Delta S}$ =0.6, then the turns for each gun will be as follows:

first gun - 22 x 0.6 = 13.....	Left 0-13;
second gun-(35 + 10)0.6 = 27.....	Left 0-27;
third gun...	without correction;
fourth gun-(63-30)0.6 = 20.......	Right 0-20.

When a large displacement angle exists which exceeds 0.3 ΔS, the concentration of the spread of bursts is not undertaken by the observer himself but by an observer placed closer to the line of fire or by the troop commander.

This is explained by the fact that due to the spread of the bursts in range it is not possible to judge the correctness of the concentration when observing from a point on the flank.

As an example, in fig 4 is given a correctly spaced concentration but to the observer, placed to the right of the line of fire, because of the spread for range the bursts of the first and third will appear as being on the same line, the bursts 2, to the right of burst 1, and burst 4, right of bursts 1 and 3.

p.15

It is perfectly understandable that to correct the pattern of the concentration by observation from a point on the flank is impossible.

Fig 4. The appearance of the correct spread of the concentration when observing from a displaced OP.

In order to concentrate the fire when observing from the gun position, the troop commander orders one or two rounds of troop fire with HE shell and with such settings of the elevation and fuze as to make the bursts visible from the gun position, and having measured the intervals, order such corrections to the guns as will give the desired concentration (according to directions from observer). In this instance the range should be roughly the same as the range to the target.

3. Determination of Target.

Fire is always preceded by the preparation of the initial settings, requiring either estimation by eye of the position of the target in relation to the gun or the plotting of the target an a map or artillery board.

The plotting of a target on a map (artillery board) as well as estimation of the position by eye are always fraught with error. For example if several observers all at the same OP plot the target on a map, then one observer may plot the target as being at point A, another one at point B, the third at point D and so on.(fig 5). In actual

The extent of the errors in plotting the target on a map has a limit and consequently the area of the possible positions of the target on the map is bounded by a line ⊱. (fig 5.)

p. 16. The same picture is obtained when the target is not plotted on a map but is pin pointed by a compass bearing and by estimating the range from the OP. In this case also because of the inevitable errors both the range and the compass bearings will be inaccurate, approximate, determined with errors different for each person who prepares the initial settings.

Consequently in this instance also, not one position of the target in relation to the gun will be determined, but as many as there are different solutions. In other words, in this case also we must begin by accepting that the true position of the target in relation to the gun is not known. What is known is the area of the possible positions of the target. The diference between the two examples quoted is that in the second one the accuracy of the calculations of the initial settings is less and therefore the area of the possible positions of the target will be greater.

Fig 5. Area of possible positions of the target.
⊱ = area of possible positions of the target.

In addition to the errors in determining the coordinates of the target errors will occur in determining the cordinates of the gun position, errors in orientation, errors in determining the meteorological and ballistic conditions etc.

All these errors will in the end affect the accuracy of the initial settings and will increase the size of the area of possible positions of the target. Errors in determining the coordinates of the target and of the gun position as well as errors in determining the meteorclogical and ballistic conditions follow Gausses law. According to this law a relation exists between the extent of the error and the probability of making it. Consequently the probability of the target being within the different sectors of the area of its possible position is not the same for each sector, and also follows Gausses law.

The fundamental statements of this law are as follows:-

1) For each method of measuring there exists in practice a limit to the extent of the errors; the probability of obtaining errors, exceeding in their absolute size, this limit is so small that it may be ignored and be considered that such errors are in practice impossible;
2) The probability of obtaining errors equal in size up or down is the same.
3) The probability of obtaining errors of unequal size is not the same: the smaller the errors the more frequently they occur.
4) The probability of obtaining errors within different limits is given below in Table 2.

In addition to this table other tables are used which are given below and in which are given the probabilities of obtaining errors within other limits.

p.17. Table 2.

Limits of errors (expressed in sizes of average errors).
Probability of obtaining errors.

In table 3 the limits of errors for which the probability is given is taken as being equal to 0.1 of the average error. In addition each column shows the probability of obtaining all errors within the limits of 0.1, on 0.05 of the average (mean) error in each direction from the extent of the error given therein. Thus, for example, the probability 0.0269 in the column of the error equal to 0- is the probability of obtaining all the errors within the limits of from -0.05 to +0.05 of the mean error; the probability 0.0268 in the error column equal to 0.1 is the probability of obtaining all errors within the limits of from +0.05 to +0.15 of the mean error, or if looking at the negative errors, from -0.05 to -0.15 of the mean error; the probability 0.0267 in the error column equal to 0.2 is the probability of obtaining all errors within the limits of from +0.15 to +0.25 of the mean error, or if looking at the negative errors, from - 0.15 to - 0.25 of the mean error and so on.

Table 4 is based on the same principle but in this case the interval is taken as being equal to 0.25 of the mean error and Table 5 where the interval is taken as being equal to 0.5 of the mean error.

Table 3.

Size of error x
Probability of obtaining errors of within the limits of from x-0.05 to x+0.05.

p.18.

This is repeated in each section of this table.

Table 4 as for Table 3 except that it is for limits of x - 0.125 to x + 0.125.

Table 5, as above but limits of x - 0.25 to x + 0.25

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Each error is related to a corresponding position of the target. It is therefore evident that the probability of the target being within a particular sector of the area of its possible positions follows Gausses law and may be determined by means of the tables given above.

p.20. In order to be able to utilize these tables in each individual case, it is necessary to know the size of the mean errors. The mean errors in the calculations of the initial settings are determined by means of numerous experiments and are given in the table below.

Table 6.

Preparation	Size of mean error. for line (in divisions of the dial sight)	for range (in % of range)
By eye		
Abbreviated		
Full		

In this manner, knowing the mean error of preparation, it is possible to determine the area of possible positions of the target, and calculate the probability of it being located on each one of the sectors of this area.

The combination of all possible positions of the target, to each one of which there is a corresponding degree of probability, is called determination of target.

The determination of the target may be given in the form of a formula which gives the degree of probability of the target being in the various areas or in the form of a table (example Tables 2. 3. 4 and 5), or in the form of a graph. The determination of the target expressed in the form of a graph will be illustrated in a separate example.

Let us take an example with the following conditions. A shortened preparation of the initial data is carried out. The range taken from a map is equal to 5,000 meters. The mean error for range in the case of a shortened preparation is equal to 4% of range, which in this case is 200 meters (4 divisions on the sight). Using table 5 let us construct a graph of the determination of the target for this example.

To this end along the horizintal axis of the graph (fig 6) let us make subdivisions to the value of $2\Delta X$ i.e. 0.5 of the mean error for range as applicable to this method of preparation. Using the subdivisions as bases let us construct rectangles whose areas to some definite extent will correspond to the probability of obtaining errors within defined limits. Having connected, by means of a curve, the centre points of the upper sides of the rectangles we obtain the curve of the determination of the target for range (curve (ABC), i.e. the curve of the probability of the target being within the different sectors of the area of possible positions of the target. Employing the curve of the determination of the target it is possible to calculate the probability of the target being within any one sector.

Thus for example, the probability of the target being within the limits 106 and 109 on the sight, in the above quoted example, will be found as a result of determining the area shaded in fig 6 (by counting the squares).

p.21. The probability being sought is 0.037 + 0.054 = 0.091.

Knowing the determination of the target we are able to solve a number of problems connected with the consolidation of the firing:

a) to order the correct sight setting while ranging;

Fig 6. Determination of the target before firing with a mean error of 200 meters ($E = 4\Delta X$).

b) calculate the probability or the mathematical expectation of hitting the target;

c) to order the correct setting of the sight or the size of the area to be engaged when firing for effect;

d) to compare various methods of ranging and firing for effect.

All these problems will be examined in detail lower down. Let us now limit ourselves to one example, which will demonstrate the idea of choosing the size of the area to be engaged.

Let us assume that as a result of the shortened preparation the range is determined as being 5,000 meters (sight 100). In this case we will have the determination of the target shown in fig 6. It is necessary to commence firing for effect without ranging provided that $B\partial = 25$ meters $= \frac{1}{2}\Delta X$.

If fire is conducted on one setting of the sights appropriate to the calculated range, i.e., sight 100, then the full zone of dispersion ($8B\partial \times 4B\partial$ in each direction from the mean trajectory) will cover an area to a depth of four divisions of the sight, from the point corresponding to sight 98 to a point corresponding to sight 102. If one should take into the zone of dispersion the four middle strips (shaded in the diagram) with the probability of hitting being 82%), i.e., the best part of the dispersion zone, then this part of the zone of disperson will cover an area of 100 meters in depth - within the limits of sight 99 - 101. The probability of the target being within this area is only 0.134. This means that firing under these conditions on the one sight setting we will on the average hit the target 13 to 14 times out of a 100, and in 86 to 87 cases out of a 100 the target will not be hit. It is evident that this reliability of fire cannot satisfy us.

p.22.

If fire is conducted on three sight settings 98, 100 and 102, then the most effective parts of the zones of dispersion will cover an area 300 meters in depth - within the limits of sights 97 -103. The probability of the target being within this area equals 0.127 + 0.134 + 0.127 = 0.388. This means that firing under the given conditions on three sight settings we may count on the shells covering the target in 39 cases out of 100, while in 61 cases out of 100 the target will be outside this zone. If fire is conducted with five sight settings - 96, 98, 100, 102 and 104, then as is seen from the diagram the probability of covering the target with the best halves of the zones of dispersion = 0.107 + 0.127 + 0.134 + 0.127 + 0.107 =0.602 i.e., in this case we may count on striking the target in 60 cases out of 100.

In firing with seven settings this figure is increased to 0.764 and in firing with nine settings to 0.872.

Therefore knowing the determination of the target it is possible to establish the dependability of fire and on this basis select the depth of the area for firing taking into account the importance of the target and the rounds allotted.

All that has been said concerning the determination of the target for range may be said equally well for the determination of the target in any direction.

The determination of the target is not only obtained as a result of preparing basic data. Further down it will be shown that in firing if one has observation over the bursts in relation to the target we will know the area of the possible position of the target and the probability of finding it within the different sectors of this area, i.e., we shall know the determination of the target.

4.
The probability of obtaining minuses and plusses under given position of the mean trajectory in relation to the target.

The dispersal of rounds in range as pointed out earlier, follows the law of Gauss, with a mean error of Bd. Taking the point C as the mean point of impact let us subdivide the area into sectors in the form of endless strips, each one being 1 Bd in depth (fig 7). The probability of the shells falling within any of the strips expressed in percentages is shown on the diagram.

Let us look at the various positions of the target in relation to the mean trajectory (the mean point of impact C).

If the target is situated beyond the mean trajectory to a distance greater than 4 Bd then it is evident not a single round can reach the target (with the exception of a negligible number of freaks) which exceed 4 Bd, which in practice are ignored); all the bursts will occur short of the target. Consequently the probability
p.23 of obtaining minuses in the case under discussion will be equal to 1, while the probability of obtaining a plus will be nil.

In the event of the target lying beyond the mean trajectory to the extent of 3 Bd (point m on the illustration), then the probability of obtaining a minus will be found to be the sum of the probabilities of striking the strips short of the target and will equal figures 2 + 7 + 16 + 25 + 25 + 16 + 7 = 98%. The probability of obtaining a plus is equal to the probability of striking the strip lying beyond the target, i.e. 2%.

Fig 7. Dispersal scale.

In the event of the target being 2 Bd beyond the mean trajectory (point 1 on the illustration) the probability of obtaining a minus will be equal to 2 + 7 + 16 + 25 + 25 + 16 = 91% and the probability of obtaining a plus will be 7 = 2 = 9%.

Making similar calculations for the probability of obtaining minuses and plusses for all the other positions of the target in relation to the mean trajectory we will obtain results shown in Table 7.

Table 7.

Distance of target from the mean trajectory.
Probability of minus
Probability of plus.

The sum of the probabilities of obtaining minuses and plusses for each one of the positions is equal to 1, as these constitute a contradiction. If the distance of the target from the mean trajectory is expressed in meters or in ΔX then in order to calculate the probability of obtaining minuses and plusses, it is necessary first of all to express this distance in the form of Bd, after which it will be possible to utilize the information given in the table above.

5. Ordering of initial setting, determination of the target prior to and after the first round.

In discussing ranging for range, we will assume that the OP is
p.24 on the line battery - target and that the observation of bursts is accurate, i.e. that the bursts are observed correctly in their relation to the target. The influence of deviation and likewise the influence of wrong (false) observations will be discussed later.

We will take a concrete example data being as follows: preparation of data - shortened, range determined by the map and found to be 5,000 meters, which corresponds to sight setting 100, Bd = 25 m. Mean error in preparation for range, E = 200 meters = 4 ΔX.

Utilizing Table 4, let us construct the curve of the determination of the target (fig 8). To do this we must write in along the first line of the table the various possible positions of the target (from setting 82 to setting 118) with an interval of 0.25 of the mean error, which corresponds to 1ΔX, On the second line of the table we write in the probabilities of the hypotheses of the target being within any of the sectors of 1ΔX in depth. The sum of all the probabilities of the hypotheses is equal to 1; this indicates that the area of the possible positions of the targets is in practice within the limits of sight setting 82 and 118.

Utilizing the values of probability written in on the second line of the table and having set oneself a definite standard, we construct the curve of the determination of the target as it is prior to the firing of the first round (curve 1).

Study of the curve of the determination of the target prior to the first round enables us to choose the initial setting of the sight before firing. This choice is based on the following considerations:

1) as seen from the table and the drawing, the probability of the target lying within the area of sight setting 100 - is the greatest.

2) The probability of obtaining a minus and a plus when firing on sight setting 100 is the same (equal to 0.5), i.e. sight setting 100 corresponds to the mean of the possible positions of the target.

As a result of these considerations, one must order the initial setting 100 i.e. the setting corresponding to the measured range.

The study of this table and the curve of the determination of the target shows that the probability of the target lying in areas close to the centre alters very slightly. Thus for example, the probability of the target lying within the area of sight setting is equal to 0.067 and within the areas of sight setting 99 and 101 the prpbability is equal to 0.066. This tells us that the greatest deviation when ordering the initial setting from the calculated range (within the limits 1 - 2 ΔX) has in practice no significance. Such deviations when giving the initial setting are made in order to round off and simplify the process of ranging.

Let us assume that on the sight setting 100 a round is fired and a minus is observed. Prior to firing we could make a number of hypotheses concerning the position of the target. Each one of these hypotheses corresponds to its own probability P_i, shown on the second line of the table fig 8.

The obtaining of a minus on the sight setting 100 gives additional information about the position of the target. Bearing in mind that B_d = 25 meters and assuming that the greatest deviation of the round from the mean point of impact does not exceed 4 B_d i.e., 100 m
/than or 2 ΔX we may state that the target cannot be closer ~~in~~/the point
p 25t which corresponds to sight setting 98. If the target is closer than this point, then firing on the setting 100 it is impossible to obtain
f 6. a minus. Consequently the series of hypptheses concerning the position of the target which we had made prior to firing the first round are washed out. The sum of the probabilities of the hypotheses prior to firing the first round as well as subsequently must be equal to 1. Following on this we may conclude that the probabilities of the hypotheses concerning the position of the target after the first round must change - in other words the determination of the target must change.

Let us now turn to the working out of the new determination of the target after obtaining a minus on the initial setting 100. For this let us employ the theorem of hypotheses. According to this theorem the probability of the hypothesis after proving is determined from the formula

$$Q_i = \frac{P_i \, p_i}{\Sigma P_i \, p_i}$$

where Q_i = the probability of some hypothesis after proving,
P_i = the probability of the same hypothesis before proving,
p_i = the probability of this hypothesis being confirmed by results,
$\Sigma P_i p_i$ = the sum of the productions of the probabilities of all the hypotheses over the probability of the hypothesis being confirmed.

The probabilities of the hypotheses prior to proving P_i is known.

The probabilities of the various hypotheses being proven , i.e. the probabilities of obtaining a minus under various positions of the target may be determined using Table 7 (page 23). If we take the hypothesis that the target is at the point corresponding to sight setting 98, i.e. 4 B_d in front of the mean trajectory, then the

P.25 * Fig. 8. Determination of the target before firing and after the first round.

probability of obtaining a minus is equal to zero. In the event of the target being at a point corresponding to sight setting 99, i.e. 2 Bd in front of the mean trajectory, the probability of obtaining a minus equals 0.09. By the same method we find the probability of obtaining a minus p_i when firing on sight setting 100 with other hypotheses as to the position of the target. The value of p_i is entered up in the third of the Table shown in fig 8.

In the fourth line is entered the production of $P_i p_i$. The sum of all the productions $P_i p_i$ is equal 0.5. According to the theorem of Hypotheses the probability of obtaining various positions of the target after trail, i.e. after firing and obtaining a minus will be found by dividing the appropriate $P_i p_i$ by $\Sigma P_i p_i$, or as in this case by dividing by 0.5. The values of Q_i are to be found in the last line of the table fig 8. The sum of the probabilities of the hypotheses of the positions of the target after firing is equal to 1 ($\Sigma Q_i = 1$).

Using the obtained values of Q_i and adhering to the previously adopted scale we construct a curve of the determination of the target after obtaining one observation (curve 11).

Having studied the table and the curve of the determination of the target (curve 11) given in fig 8, we see that the determination of the target after the first round is fired differs considerably from the determination of the target prior to firing.

p.27 First of all it is necessary to note the considerable diminution of the area of the possible positions of the target. While prior to firing the area of the possible positions of the target was 36 ΔX (from setting 82 to setting 118) after the first observation the depth of this area was equal to only 20ΔX (from setting 98 to setting 118) i.e., it has reduced itself by almost a half. Prior to firing the most probable position of the target was at a point corresponding to setting 100. Having obtained a minus when firing on setting 100 the most probable position of the target, as is evident from the last line of the table and of the curve 11(fig 8) is to be found at a point which corresponds to setting 102. The probability of the target being on any of the sectors within the limits of from setting 102 to setting 118 has increased by exactly twice the amount.

Prior to firing the curve of the determination of the target was symmetrical; the point corresponding to the sight setting 100 on which the probability of the target being found is the greatest, was at the same time the mean point of the determination, as the probability of the target being situated to one or the other side of the point is the same (0.5). In addition this point was the centre point of the area of the possible positions of the target.

Having obtained a minus at setting 100 the curve of the determination of the target became assymmetrical. The most probable position of the target as indicated above, is at a point corresponding to setting 102, while the mean point of the determination of the target corresponds to setting 104. The probability of the target being to one or the other side of this point is the same. Finally the center point of the whole area of the possible positions of the target is a point corresponding to setting 108.

6. Width of first bracket.

Ranging for range by observation of bursts is done by means of bracketting the target and of subsequent narrowing of the bracket. How wide must this bracket be, or in other words by how much must the sight setting be altered for the second round?

Let us clarify first of all the causes which determine the width of the first bracket. If the distance to the target had been determined absolutely accurately and if corrections for meteorological and ballistic conditions were likewise determined absolutely accurately, then having obtained the first observation of burst there would be no necessity for altering the sight setting, i.e. in making a bracket, as the obtaining of a plus or a minus under these conditions would be merely the result of dispersal within the 100 zone.

However, if in estimating range an error is introduced, then it is obvious that having observed the first burst, the setting must be altered and the greater the error in preparation, the greater must be the alteration of the setting, i.e., the greater must be the width of the first bracket.

p.28. In view of the fact that each method of preparation has its own degree of accuracy, it follows that the width of the first bracket will depend on the method chosen for preparing the initial data.

In order to ensure the bracketting of the target it would be necessary to alter the sight setting for the second round by the amount of the maximum error of preparation, i.e., in practice by 4 - 5 mean errors. It is necessary to bear in mind, however, that the bracketting of the target with the first bracket does not conclude ranging, which is continued until a narrower bracket is obtained which enables the observer to go to fire for effect; Therefore ranging with the first bracket having a width of from 4 - 5 mean errors would be in most cases an excessive waste of shell and consequently an excessive wastage of time. Excessively small corrections would result in unnecessary waste of shell and time prior to obtaining the first bracket.

Let us determine the width of the first bracket on a basis of the most economic use of shell to be expended in ranging.

To this end let us calculate mathematically the expected expenditure of rounds for ranging prior to obtaining a long and a short bracket under the conditions that the first bracket is equal to 4, 2, 1 and ½ of the mean error of preparation, which in the case of our example is 16, 8, 4 and 2 divisions of the sight. After comparing the results of the calculations it will become evident how wide the bracket ought to be.

The determination of the target after obtaining a plus on sight setting 100 has already been calculated and the results of the calculations are presented in the form of a table and are given in the form of a graph in fig 8.

In calculating mathematically the expected expenditure of rounds we shall look at the sectors with a depth of two divisions of the sight. Employing the table and the graph fig 8, we will construct a table of probability of the target being within these sectors (Table 8).

<u>Table 8</u>.

Sight settings 98	etc	etc
Probability of location of target		

We will first of all calculate the mathematical expectation of expenditure of rounds for ranging (ranging being carried out until a long and a short bracket have been obtained) with the condition that the width of the first bracket is equal to 4 mean errors of preparation which in the case of our example is 16 divisions of the sight.

Let us look at the various possible positions of the target after having obtained a minus on sight setting 100. Assuming that the target
p.29. lies within the sector bounded by sight settings 100 and 102, then having fired the second round on sight setting 116 we will obtain a plus. Halving the bracket, with the third round, on setting 108 we will obtain a plus. The fourth round on setting 104 will give a plus and finally the fifth round, on setting 102 we will obtain the required bracket of two divisions of the sight 100 - 102.

Thus if the target is within the sector bounded by settings 100 and 102 to obtain a 'two division' bracket, with the first bracket being equal in width to four mean errors, it is necessary to use five rounds. Arguing along the same lines it is not difficult to see that in the event of the target being in any other position within the limits of from sight setting 98 to sight setting 116, the expenditure of rounds will be the same, i.e., five rounds.

For example if the target is within an area bounded by sight settings 110 and 112 then the sequence of ranging rounds in this instance will be as follows:

Setting 100 - minus;
" 116 - plus;
" 108 - minus;
" 112 - plus;
" 110 - minus.

Consequently in this particular position of the target the expenditure of rounds for ranging equals five.

If the target is to be found in an area between settings 116 and 118, to obtain a 'two division' bracket it is necessary to expend six rounds:

Setting 100 - minus;
" 116 - minus;
" 132 - plus;
" 124 - plus;
" 120 - plus;
" 118 - plus.

Thus in each instance when the target is within the limits of settings 98 and 116, the expenditure of rounds for ranging will be five and when the target is within the limits of settings 116 and 118 the expenditure will be six rounds. But the probability of the target being between the settings 98 and 116 (see table 8) equals ;

$$q_1 + q_2 + q_3 + q_4 + q_5 + q_6 + q_7 + q_8 + q_9 = 0.994.$$

Consequently the prpbability of expending five rounds for ranging also equals 0.994.

The probability of the target being within an area bounded by settings 116 and 118 and consequently also the probability of expending six rounds for ranging is expressed as;

$$q_{10} = 0.006.$$

Therefore the mathematical expectation of expenditure of rounds for ranging will be ;

$$a = 5(q_1 + q_2 + q_3 + q_4 + q_5 + q_6 + q_7 + q_8 + q_9) + 6q_{10} =$$
$$= 5 \times 0.994 + 6 \times 0.006 = 5.006.$$

p.30 Let us now calculate the mathematical expectation of expenditure of rounds for ranging (up to the obtaining of a 'two division' bracket), if the first bracket is being obtained by alterations of the sights equivalent to 2 mean errors, i.e., 8 divisions of the sight. Arguing on the same lines as previously we come to the deduction that for ranging we shall expend four rounds in the case of the target being within the sight settings 98 and 108, five rounds when the target is between 108 and 116 and six rounds when the target/is between sight settings 116 and 118.

Consequently the mathematical expectation of rounds will be ;

$$a = 4(q_1 + q_2 + q_3 + q_4 + q_5) + 5(q_6 + q_7 + q_8 + q_9) + 6q_{10} =$$
$$= 4 \times 0.824 + 5 \times 0.170 + 6 \times 0.006 = 4.182.$$

When obtaining the first bracket with sight alterations equivalent to one mean error, i.e., four divisions, the mathematical expectation of expenditure of rounds is ;

$$a = 3(q_1 + q_2 + q_3) + 4(q_4 + q_5) + 5(q_6 + q_7) + 6(q_8 + q_9) + 7q_{10}$$
$$= 3 \times 0.500 + 4 \times 0.324 + 5 \times 0.134 + 6 \times 0.036 + 7 \times 0.006 =$$
$$= 3.724.$$

When obtaining the first bracket with sight alterations equivalent to half of a mean error, i.e., two divisions, the mathematical expectation of expenditure of rounds is:

$$a = 2(q_1 + q_2) + 3q_3 + 4q_4 + 5q_5 + 6q_6 + 7q_7 + 8q_8 + 9q_9 + 10q_{10} =$$
$$= 2 \times 0.263 + 3 \times 0.237 + 4 \times 0.189 + 5 \times 0.135 + 6 \times 0.085 +$$
$$+ 7 \times 0.049 + 8 \times 0.025 + 9 \times 0.011 + 10 \times 0.006 = 3.880.$$

The results of the clacûlations are brought together in table 9.

Table 9.

For bracketting target with $2\Delta X$ bracket.

Width of first bracket	Ranging rounds required
4 mean errors	5.006
2 mean errors	4.182
1 mean error	3.724
½ mean error	3.880

The study of Table 9 enables us to deduce that the least expenditure of rounds and consequently of time required for ranging is achieved when the first bracket is equal in width to one mean error (in this instance this is four divisions of the sights).

This deduction is made on the basis of the results of calculations made for a particular case (shortened preparation at a range of 5,000 m) ranging being carried out until a 'two division' bracket is obtained. In addition in calculating the expenditure of rounds for ranging, the dispersal of rounds was not taken into account. Nevertheless the deduction made is applicable to all other ranges and for other forms of preparation; this is easily proven by making the appropriate calculation. If the last bracket does not equal $2\Delta X$ as was the case in our example but equals something else then the expenditure of rounds will vary by a constant figure for all cases. For example if ranging is conducted until a one division bracket is obtained then in calculating the expenditure of rounds it would be necessary to take into account an additional halving of the bracket, i.e., in all cases the additional expenditure of one round and all figures in table 9 would have to be increased by one. (1). It is evident that this does not in any way alter the deductions already made concerning the most profitable width of the first bracket.

1.31.

The calculations, as mentioned above, were made without dispersal being taken into account, this fact considerably facilitating the solution of the problem. The taking into account of dispersal likewise cannot alter the deduction made as the influence of dispersal will be the same whatever the width of the first bracket. Consequently for all methods of preparation and for all ranges the width of the first bracket must be equal to one mean error of the estimation of range.

In table 10 are given the mean errors of estimating range under the various methods of preparation.

Table 10.

Preparation.	Mean error expressed as % of range.	Mean error in divisions of sight (ΔX = 50 m) according to range. 1 km	2 km	3 km	4 km	5 km	6 km	etc.,
By eye								
Shortened								
Full								

Expressing these figures in round numbers to assist memorising and to facilitate their use when firing we get the following widths of the first bracket. (Tables 11 and 12).

Table 11.

Preparation	Width of first bracket in divisions of the sight (ΔX = 50 m) according to the range. up to 3 km.	from 3km to 6 km.	more than 6 km.
Visual (by eye)			

p.32

Table 12.

Preparation	Width of first bracket in divisions of the sight ($\Delta X = 50$) according to the range.		
	up to 3 km.	from 3 km to 8 km.	more than 8 km.
Shortened.			

In the case of a full preparation the width of the first bracket for all ranges may be taken as being $2\Delta X$.

However on the basis of the considerations relating to the width of the last (short) and not the first bracket (see page 44), Rules for Firing 1945 lay down a somewhat different width for the first bracket in the case of a full preparation, as follows:

ranges up to 8 km with $B_d < 40$ m..........2 divisions (100 m)
" " " " " $B_d > 40$ m..........4 " (200 m)
" exceeding " " $B_d < 80$ m..........4 " (200 m)
" " " " $B_d > 80$ m..........8 " (400 m)

In other words in the case of full preparation of the initial data the first bracket should be 4 B_d because a bracket of this width is also the last bracket (short)(see page 44).

On the basis of figures given in Table 9 in firing mortars one tries for a bracket of the following width (in metres) (Table 12a).

Table 12a.

Preparation	Range		
	UP TO 1,500 m.	from 1,500 to 3,000 m	above 3,000 m
Visual			
Shortened			

If after the first alteration to the sight the bursts are found to be on the same side of the target as before, i.e. the target is not bracketted, another alteration of the same size is made

All the considerations have been based on the assumption that lateral displacement of the bursts is not measured and only the plusses and minuses are determined. If however, the first observation for range indicates a considerable error in the determination of the initial data then the width of the first bracket (irrespective of the method of preparation) is taken as 8, 16 or more divisions of the sight, depending on on the extent of the error determined by eye or from the map.

If the first observation shows that the burst is close to the target and that the bracket of four or eight divisions of the sight is obviously too great the alteration of the sight is either halved or is taken to be of a size determined in the course of ranging by the size of the displacement.

p.33 In the event of the first round falling very close to the target fire is repeated at the same sight setting.

7. Shortening of Bracket.

The correct initial setting of the sight was deduced from the determination of the target which was calculated on the basis of our knowledge of the errors of preparation. The study of the determination of the target after the initial round made it possible to make the deduction concerning the width of the first bracket i.e. concerning the setting of the sights for the second round. In order to establish rational rules for subsequent ranging it is necessary to calculate the determination of the target as it will be after the target is taken into the first bracket. We will make the analysis using an example under the same conditions of firing as in the case of determining the width of the first bracket i.e.,

(a) preparation - shortened (mean error 4% A);
(b) range from gun to target determined as 5,000 m;
(c) all observations of bursts correct i.e. the fall of shot corresponds to the observation of plus or minus;

(d) ΔX = 50 m; $B\partial$ = 25 m;
(e) on sight setting 100 a minus is obtained, while on sight setting 104 a plus, i.e. the target is enclosed in a bracket divided into four.

Figure 9 shows the calculations for the determination of the target after obtaining this bracket.

The first line of the table gives the sectors of the area of the possible positions of the target, each one to a depth of $1\Delta X$, within limits of from sight setting 98 to sight setting 118.

The second line gives the probability of the target being within these sectors after obtaining a minus on sight setting 100. The data for this line are taken from Table fig 8. On this data is based the construction of the curve of the determination of the target after the first round (fig 9 - curve ADE).

The third line gives the probabilities of obtaining a plus on sight setting 104 with the target in various positions.

result The fourth line gives the probabilities of a compound ~~[illegible]~~ ~~contingency~~: the target being within a given sector and the obtaining of a plus. As is already known, the probability of a compound result is equal to the sum of the simple results which go to make up the compound results. In this case it happens to be the sum of the figures found in the second and third lines of the table.

The last line of the table gives the probabilities of the target being within the various sectors after obtaining a bracket divided four times, i.e., the determination of the target of the target is given.

The figures in this line are worked out according to the formula of the theorem of hypotheses:

$$Q_i = \frac{P_i \cdot p_i}{\Sigma P_i p_i}$$

P.34. where

Q_i - the probability of the hypothesis after trial; in this case - probability of the target being within one of the sectors after the second round;

P_i - the probability of the same hypotheses prior to trial; in this case - probability of the target being within the same sector before the second round (after the first round);

p_i - the probability of the accuracy of the hypothesis; in this case - the probability of obtaining a plus on sight setting 104 with the given position of the target.

From the information within this line a curve is constructed of the determination of the target after obtaining a bracket - curve ABC.

A study of the table and the graph in figure 9 allows one to make the following deductions.

Prior to obtaining a bracket i.e. after the first round, the depth of the ~~[illegible]~~ area of the possible positions of the target was equal to $20\Delta X$ or $40 B\partial$ (within the limits of sight settings 98 - 108). After the second round the depth of the area of the possible positions of the target became equal to $8\Delta X$ or $16 B\partial$ (within the limits of sight settings 98-106), i.e. decreased by 2.5 times. The probability of the target being within the sector CE (between sight settings 106-118) became equal to nil, and as a result the probability of the target being within the sector AC increased (between 98 - 106). Consequently as a result of obtaining the second observations our information about the positions of the target has become more precise.

The area of the possible positions of the target is made up of the sector within the bounds of the bracket (between 100 - 104) and of sectors beyond the limits of the bracket, 4 Bd on either side.

After the first round the curve of the determination of the target ADE, was obviously assymetrical. After obtaining the bracket as may be seen from the table and the graph the lack of symmetry in the curve (ABC) became quite negligible. Within reasonable limits it may be said that the point corrésponding to sight setting 102 i.e. the centre of the bracket obtained is the point on which the target is most likely to lie; this point is the mean point of the determination of the target i.e. such a point in relation to which the probability of the target corresponding to it is roughly equal; and finally this point is the centre of the area of the possible positions of the target.

On the basis of all that has been said it is possible to make the deduction that the next round must be fired with a sight setting corresponding to the middle of the bracket, i.e., the shortening of the bracket must be done by the process of halving.

But how, after all, is the fact to be explained that the curve of the determination of the target after obtaining the bracket was found to be not completely symmetrical and that the maximum of the curve (the point corresponding to the most probable position of the target) is out of place although slightly, in relation to the centre of the bracket? In our example the maximum of the curve as may be seen from the table and the graph is slightly to one side of the point corresponding to sight setting 100. This is explained by the
p.36. fact that the conditions which are being analysed by us include the determining of the target by two methods: first of all as a result of the preparation of initial data and secondly as a result of ranging. In preparaing the initial data the range to the target is determined as being equal to 5,000 m, which corresponds to sight setting 100.

Sight settings
Probability of location of target after first shot (P_i).
Probability of obtaining a plus with sight setting 104 (p_i).
The same, taking into account the determination of the target ($P_i p_i$).
Probability of location of target after obtaining a bracket of 100 - and 104 + (Q_i).

p.35 Fig 9. The determination of the target after obtaining a "four-division" bracket 100 - and 104 + taking into account the preparation of initial sight settings.
ADE = curve of the determination of the target after obtaining a minus at sight setting 100.
ABC = the curve of the determination of the target after obtaining a "four-division" bracket.

In ranging a minus is obtained on sight setting 100 and a plus on sight setting 104. As the degree of displacement of both bursts was not measured , then on the basis of the results of ranging alone (without taking into account the data of the preparation of the initial sight settings) we should have accepted the range to the target corresponding to the centre of the bracket i.e. sight setting 102.

Thus we have two results: sight setting 100 and sight setting 102.

If both were equal in value as far as accuracy is concerned then the most probable position of the target would be the mean point i.e. the point corresponding to the sight setting 101. The position of the highest point of the curve in the case of our example is considerably closer to sight setting 102; this is explained by the fact that the obtaining of a "four divisional" bracket gives much more accurate information about the position of the target than the preparation of the initial settings, charecterized by the mean error E = 4%, Д = 200 m.

Consequently the taking into consideration of the preparation of the initial settings has little effect on the appearance of the curve of the determination of the target after obtaining a bracket.

Therefore, in all future calculations for the sake of simplicity, we will not take into account the preparation of initial settings.

Working on this basis let us calculate the determination of the target after obtaining the same "four division" bracket when on sight setting 100 a minus was obtained and a plus on sight setting 104.

For greater clarity let us take sectors of a lesser depth, i.e. of $\frac{1}{2}\Delta X$, which gives us 1B∂.

The table and the results of calculations are given in fig 10. According to the data shown in the bottom line a curve is drawn giving the determination of the target (curve ABC). As expected in this instance the curve of the determination of the target is completely symmetrical and the most probable position of the target is the centre of the bracket obtained (in this case sight setting102). Studying the determination of the target we come to the conclusing that we cannot commence firing for effect on the strength of the "four division" bracket as the area of the possible positions of the target is too great (16 B∂) and consequently it is necessary to shorten the bracket obtained. The shortening of the bracket must be done by the process of halving i.e. giving the sight setting for the next round corresponding to the centre of the bracket. Firing a round on the setting corresponding to the centre of the bracket obtained (in this instance sight setting 102) we may expect with equal probability the obtaining of either a plus or a minus.

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p.37.

Sight settings.
Probability of obtaining a minus at sight setting 100.
Probability of obtaining a plus at sight setting 104.
Probability of obtaining a bracket 100 (-) 104 (+)
Probability of locating the target after obtaining the bracket 100 (-) 104 (+).

Fig 10. Determination of the target after obtaining a "four division" bracket 100 (-) and 104 (+), without taking into account the preparation of initial sight settings.

ABC is the curve of the determination of the target after obtaining a "four division" bracket.

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p.38

Sight settings.
Probability of obtaining a minus at sight setting 100.
Probability of obtaining a plus at sight setting 102½
Probability of obtaining a bracket 100 (-) 102 (+).
Probability of locating the target after obtaining the bracket 100 (-) 102 (+).

Fig 11. Determination of the target after obtaining a "two division" bracket 100 (-) and 102 (+),.
ADE is the curve of the determination of the target after obtaining a "two division" bracket.

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p.39.

Let us assume that on sight setting 102 a plus is obtained i.e. the target has been bracketted between sight settings 100 (-) and 102 (+).

Let us work out the determination of the target after obtaining this bracket.

The method of calculating is exactly the same as in the case of a "four division" bracket. The table and the results of the calculations are given in fig 11. According to the data found in the bottom line of the table a curve of the determination of the target after obtaining a 'two division bracket' is constructed (curve ADE). For comparision the curve of the determination of the target after obtaining a "four division" bracket is also given in the same figure (curve ABC).

Basing oneself on the study of the curve of the determination of the target (curve ADE) it is possible to make the following deductions:

1. After obtaining a 'two division' bracket the area of possible positions of the target is equal to the width of the bracket (4 B∂ on either side). With B∂ being

25 metres the area of possible positions of the target after obtaining a "two division" target is equal to 4 Bd + 8 Bd = 12 Bd or 6 Δ X.

2. The most probable position of the target - centre of the bracket obtained (in this instance within the sector of sight setting 101)

The study of the determination/of the target/after obtaining "four division" or "two division" brackets enable us to summarize the deductions obtained in respect of brackets of any length:

(a) the area of possible positions of the target after obtaining a bracket with one sign at either end is equal in width to the length of the bracket itself plus 8 Bd;

(b) the most probable position of the target - centre of the bracket obtained.

With this as a basis let us work out the areas of the possible positions of the target for brackets of varying length and let us tabulate the data obtained (Table 13).

Table 13.

Bracket	Area of possible positions of the target expressed in	
	Δ X	Bd
Before shooting with shortened preparation		

P.40 Table 13 enables us to assess the change in the determination of the target in relation to the halving of the bracket. With every round fired the area of possible positions of the target decreases. At the same time the probability of the target being within the separate sectors of this area increases. Thus for example the probability of the target being within the sector between sight settings 100 and 102 prior to firing (see fig 8) is equal to 0.13, after obtaining a minus on setting 100 the probability of the target being within the same sector becomes equal to 0.22, after obtaining a bracket 100 (-) and 104(+) the probability of the target being within the sector between sight settings 100 and 102 has increased to 0.43 (fig 10) and finally after obtaining a bracket 100 (-) and 102 (+), the probability in question has increased to o.71 (see fig 11).

Thus bracketting a target and subsequent halving of this bracket makes our information concerning the position of the target more precise, lessens the number of sight settings on which fire is to be conducted, at the same time increasing the probability of locating the target within certain sectors of the area and consequently increasing the probability of striking the target.

However, from a study of Table 13 we see that in halving an "eight division" bracket the area of possible positions of the target decreases from 24 to 16 Bd; in halving a 'four division' bracket, this area decreases only by 4 Bd and finally in halving a 'two division' bracket only by 2 Bd i.e. each subsequent halving becomes less and less advantageous. This is explained by the fact that in halving a bracket the only part of the area that decreases by half is the part lying between the extremities of the bracket (i.e. the length of the bracket itself), the part of the area of the possible positions of the target which lies beyond the extremities of the bracket and equal to 8 Bd remains unchanged. From this we can establish that shortening of the bracket may only be carried out up to some definite limit beyond which any further shortening brings no material advantage. In order to find out the necessary length of the final bracket let us consider the question of verifying the bracket.

8. Verifying the Bracket.

Reducing the area of possible positions of the target may be achieved not only by halving the bracket but also by verifying the extremities of the bracket obtained. To establish this point let us analyize the case of a "two division" verified bracket 100 (- -)* and 102 (++).

* (A confirmed bracket i.e. a verified bracket, is a bracket with not less than two observed rounds at each extremity: at the near end at least two minuses and at the far end at least two pluses).

Let us first of all find out the probability of obtaining two minuses when firing on setting 100 with a target in various positions. The obtaining of two minuses constitutes a compound result consisting of two simple ones (first minus and second minus), and therefore to find out the probability of obtaining this compound result it is necessary employ the theorem of multiplication. p.42.

Sight settings.

Probability of obtaining 2 minuses at sight setting 100.

Probability of obtaining 2 plusses at sight setting 102.

Probability of obtaining bracket 100 - - and 102 + +.

Probability of locating the target after obtaining the bracket 100 - - and 102 + +.

P...

Fig 12. Determination of the target after obtaining a "two division" verified bracket 100 - - and 102 + +.

ADE curve of the determination of the target after obtaining a "two division" unverified bracket 100 - and 102 +.

KIM the curve of the determination of the target after obtaining a "two division" verified bracket 100 - - and 102 + +.

Let us suppose that the target is to be found on sight setting 100 i.e. at a point through which the mean trajectory passes. Then the probability of obtaining a minus with one round is equal to 0.5. The probability of obtaining two minusses with two rounds will be $0.5^2 = 0.25$ (fig 12).

In the case of the target being at a point corresponding to sight setting 99.5 the probability of obtaining a minus is 0.25; the probability of obtaining two minuses with two rounds is $0.25^2 = 0.063$ and so on. The probabilities worked out in this manner i.e. the probabilities of obtaining two minuses on sight setting 100 with the target in various positions are given in the second line of fig 12.

The probabilities of obtaining two plusses when firing on sight setting 102 with the target in various positions are worked out in the same way (third line of fig 12).

Employing the theorem of multiplication we will obtain the probabilities of achieving two minuses on sight setting 100 and two plusses on sight setting 102, i.e. the probabilities of bracket 100 - - and 102 + + with the target in various positions (4th line).

Let us take the sum of the probabilities of obtaining the bracket with the target in various ppsitions. It is 2.4.

Having divided each figure in the fourth line of fig 12 by 2.4 we obtain the probabilities of the target being within the various sectors i.e. we obtain the determination of the target. The result of this division is given in the fifth line of fig 12.

The determination of the target in graph form, after obtaining the bracket 100 - - and 102 + + is represented by the curve KIM. For the purpose of comparison on the same diagram the curve of the determination of the target, after obtaining an unverified "two division" bracket 100 - and 102 + is also given.

From a study of the curve of the determination of the target KIM, we see that in repeating the extremities of the bracket we have reduced each side of the area of the possible positions of the target by 1½ Bd, in all by 3 Bd. Prior to repeating the rounds on the extremities, the area of possible positions of the target was AE = 4 Bd + 8 Bd = 12 Bd and after repeating the rounds on the extremities became IM = 4 Bd + 5 Bd = 9 Bd. Thus the process of repeating the rounds on the extremities leaves the size of the bracket unchanged but reduces that part of the area which lies beyond the limits of the bracket. At the same time the probability of the target being within the specific sectors of this area increases and consequently the probability of striking the target on settings appropriate to these sectors also increases.

Thus, for example, the probability of the target being within the sector between sight settings 100 and 102 prior to repeating the rounds on the extremities was 0.71, after repeating the rounds on the extremities, this probability increased to 0.86.

Thus the reducing of the area of the possible positions of the target as well as the increasing of the probability of the target being within specific sectors of this area may be achieved by halving the bracket and also by repeating the rounds on the extremities of the bracket. In order to determine to what point it is necessary to halve a bracket and when it is necessary to go over to repeating rounds on the extremities let us tabulate the sizes of the areas of the possible positions of the target after obtaining various brackets. (Table 14).

p.43.

Table 14.

Width of bracket in ΔX and the number of signs on each extremity.	Area of possible positions of the target expressed in Bd ($Bd = \frac{1}{2} \Delta X$)		
	Internal part.	External part	Whole area

The study of Table 14 allows us to make the following deductions:

1. The repeating of rounds on the extremities of a "four division" bracket reduces the area of possible positions of the target from 16 to 13 Bd i.e. by 3 Bd while halving a "four division" bracket will reduce the same area from 16 to 12 Bd i.e. by 4 Bd. If in addition one takes into account that the repeating of rounds on the extremities requires the expenditure of two rounds while the halving of a bracket requires only one round, then it becomes perfectly obvious that the repeating of rounds on the extremities of a "four division" bracket should not be undertaken; a "four division" bracket should be halved.
2. The repeating of rounds on the extremities of a "two division" bracket reduces the area of possible positions of the target from 12 Bd to 9 Bd whilst halving the bracket reduces the same area merely from 12 Bd to 10 Bd.

If one takes into account that with the approach of the mean trajectory to the target the number of wrong observations increases, it becomes obvious that after obtaining a "two division" bracket halving should not be done but the rounds on the extremities should be repeated. By this means one first of all achieves a greater reduction of the area of possible positions of the target than in halving the bracket and in addition the probability of obtaining on either extremity of the bracket two wrong observations becomes very small.

From the above the following rule may be arrived at: "When firing at short or medium ranges (when Bd is approximately $\frac{1}{2}\Delta X$) the shortening of the bracket must be attained by means of consecutive halving until a "two division" bracket is achieved; after this the rounds on the extremities of the "two division" bracket obtained, are repeated.

At long ranges Bd reaches ΔX and over."

The size of the areas of possible positions of the target after obtaining brackets of various sizes when firing at long range, are given in table 15.

p.44.

Table 15

Width of bracket in ΔX and the number of signs on each extremity.	Area of possible positions of the target expresses in Bd ($Bd = \Delta X$).		
	Internal part	External part	Whole area

From a study of Table 15 it is evident that if the areas of the possible positions of the target are expressed in terms of Bd, then a "four division" bracket at long range corresponds to a "two division" bracket at medium range. Therefore, all that has been said above concerning "four and two division" brackets must be appropriately related to "eight and four division" brackets at long range.

Consequently, when firing at long range in cases where Bd is close to Δ X, a "four division" bracket should not be halved, instead the rounds on its extremities should be repeated, after which firing for effect should commence. Generally speaking the less the dispersal the shorter must be the final bracket and conversely the greater the dispersal the greater must be the final bracket and the greater the importance of repeating ~~of repeating~~ the rounds on its extremities.

Summarizing the deductions arrived at earlier it may be stated that, "the width of the final bracket which should be verified =4 Bd

Therefore, when firing guns which have sights calibrated in thousandths (value of Δ X variable), the halving of the bracket is carried out until the bracket obtained is 100 metres with Bd less than 40 metres and 200 metres with Bd more than 40 metres.

When firing mortars the bracket obtained is halved until a bracket of 50 metres is obtained at ranges of up to 2 kilometres and a bracket of 100 metres at ranges of from 2 to 4 kilometres, a bracket of 200 metres at ranges exceeding 4 kilometres, based on the mean values of Bd at these ranges (Table 16).

Table 16

Range in kilometres	Size of Bd with charges							4 Bd approx.	Width of short bracket in metres.
	1st	2nd	3rd	4th	5th	6th	Avge approx		

p.25.

It remains to answer the question relating to the verification of the bracket - how many signs must one have at each of the ends?

To this end let us work out the determination of the target after obtaining a "two division" bracket with three signs at each end, i.e. a bracket 100 - - - and 102 + + +.

The method of calculation is the same as for all preceding cases. The results of calculations are given in fig 13.

Graphical presentation of the determination of the target after obtaining a bracket 100 - - - and 102 + + + is expressed as curve NPR. For comparison on the same drawing are given the following curves of the determination of the target: KLM, after obtaining a bracket 100 - - and 102 + + and ADE, after obtaining a bracket 100 - and 102 +.

Comparing these two curves we see the following.

Whilst the first repetition of the round on the extremities (only two signs on each of the ends) decreases the area of the possible positions of the target by 3 Bd, the verification of the bracket by means of a third sign on each of the ends narrows the area of the possible positions of the target only by 1 Bd - by ½Bd on either side.

Verification of the extremities by means of a fourth sign gives an even smaller advantage. Therefore, in verifying a 'two division' bracket it is sufficient to limit oneself to obtaining two signs on each of the ends.

In view of the fact that the most probable position of the target in all cases is the centre of the bracket obtained, then fire for effect should be carried out on the sight setting which corresponds to the centre of the verified bracket.

9. The Covering Group.

The combination of plusses and minuses obtained at the one sight setting is called the covering group.

A covering group may contain a varying proportion of signs. Thus, for example, a covering group of six bursts may have the following proportion of signs:

5:1 - 5 minuses and 1 plus or 5 plusses and 1 minus;
4:2 = 2:1 - 4 minuses and 2 plusses ~~and~~ or 4 plusses and 2 minuses;
3:3 = 1:1 - equal number of plusses and minuses.

The particular form of a covering group possessing an equal number of plusses and minuses is called a nil bracket.

A covering group as well as a bracket may be either verified or unverified.

A covering group is considered to be verified when it contains not less than observed plusses and two observed minuses; for example 4 minuses and 2 plusses or 3 minuses and 3 plusses.

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p.46

Sight settings
Probability of obtaining 3 minuses at sight setting 100.
Probability of obtaining 3 plusses at sight setting 102.
Probability of obtaining bracket 100 - - - and 102 + + +
Probability of locating target after obtaining a bracket 100 - - - and 102 + + +.

Fig 13. Determination of the target after obtaining a "two division" verified bracket 100 - - - and 102 + + +
NPR = curve of the determination of the target after obtaining a "two division" verified bracket 100 - - - and 102 + + + .

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p.47.

A covering group is considered to be unverified if there is only one observation of one of the signs; for example 3 minuses and 1 plus, 1 plus and 1 minus, 1 minus and 5 plusses.

In order to determine on which sight setting subsequent firing is to be conducted let us work out the determination of the target after obtaining covering groups with varying proportions of signs.

Sight settings.
Probability of obtaining a minus on setting 100.
Probability of obtaining a plus on setting 100.
Probability of obtaining a covering group on setting 100.
Probability of locating the target after obtaining a covering group (-&+)

Fig 14. Determination of the target after obtaining an unverified covering group on sight setting 100 (- & +)

Let us assume that on sight setting 100 with our first round we obtained a minus, in repeating this end of the bracket we obtained a plus, i.e. on sight setting 100 we have an unverified covering group. Let us work out the determination of the target for this particular case. The results of the calculations are given in fig 14. Employing the data given on the fifth line of the table we construct a curve of the determination of the target after obtaining an unverified covering group (-+) on sight setting 100. From the table and the curve of the determination of the target we see that the mean and at the same time the most probable position of the target corresponds to sight setting 100. The depth of the
/area
whole/of the possible positions of the target equals $4\Delta X$ or $8 B_d$. The probability of locating the target within the sectors of sight
p.48. settings 99 and 101 is relatively small (approximately three times less than within the sector of sight setting 100). Taking all this into account, one must come to the conclusion that further shooting must be carried out on one sight setting, and namely on that setting on which the covering group was obtained; in this case sight setting 100. When continuing the shooting it is possible to obtain either an equal number of plusses and minuses or the predominance of one type of sign over another.

Sight settings.
Probability of obtaining two minuses at sight setting 100,
Probability of obtaining of one plus at sight setting 100.
Probability of obtaining minus, minus, plus at sight setting 100.
Probability of locating the target at sight setting 100 after obtain-ing minus, minus, plus.

Fig 15. Determination of the target after obtaining an unverified covering group on sight setting 100 (- - +).

In the event of another minus and another plus being obtained the area of the possible positions of the target decreases (1½ Bd on either side, 3 Bd in all), the most probable position of the target remains within the sector of the sight setting on which the covering group was obtained. Consequently subsequent fire for effect is carried out on the same sight setting.

In the event of a covering group being obtained with a predominance of one sign over another then the most probable position of the target will not correspond to the sight setting on which the covering group has been obtained but will be some distance away from it depending on the relative position of the signs.

p.49 In order to establish how firing is to be carried out after an unverified govering group with a varying proportion of signs has been obtained, let us work out the determination of the target after obtaining an unve-rified covering group minus, minus, plus and minus, minus, minus, plus.

The tables and the results of the calculations for the covering group minus, minus, plus, are given in figure 15 and for covering group minus, minus, minus, plus, in figure 16.

Sight settings.
Probability of obtaining 3 minuses at sight setting 100.
Probability of obtaining 3 plusses at sight setting 100.
Probability of obtaining – – – + at sight setting 100.
Probability of locating the target after obtaining – – – + at sight setting 100.

Fig 16. Determination of the target after obtaining an unverified covering group at sight setting 100 (– – – +).

Studying the curves of the determination of the target we see that after obtaining an unverified covering group with a sign ratio of two to one (in our example two minuses and one plus), the most probable position of the target is within the sector between sight setting 100 and 100.5, i.e. displaced from the sight setting on which the covering has been obtained by less than 1 Bd. Consequently it would not be correct to alter the setting of the sights for further firing.

50. After obtaining a covering group with a sign ratio of three to one (in our examples three minuses and one plus) the most probable position of the target is displaced from the sight setting on which the covering group had been obtained by 1 Bd. In our example this corresponds to sight setting 100.5.

Summarizing the deductions made above, the following rule may be given: if while trying for a bracket or if while repeating rounds on its extremities an unverified covering group is obtained on a sight setting, firing continues on this setting until a sign ratio is less than three to one. In the event of the sign ratio being three to one the sight setting is either left unaltered or it is altered to the extent of 1 Bd in the direction of the smaller number of signs. In the event of the sign ratio being greater than three to one the sight setting is altered to the extent of 2 Bd (or by one division of the sights, when X = 50 metres) in the direction of the smaller number of signs.

If after such an alteration of the sight setting a predominance of bursts of the other sign is obtained, exceeding three to one an intermediate correction is made for elevation or to the sight setting in the opposite direction.

10. Sequence of ranging.

In laying down the principles of ranging with HE by the method of observation of bursts directions were given confirmed by calculations, concerning the ordering of the initial sight settings, the length of the initial bracket, the sequence of halving a bracket and the repetition of rounds on its extremities, and finally for the selection of the most advantageous sight setting for subsequent firing.

In view of the fact that the expenditure of rounds and time on ranging depends not only on the selection for each round of an appropriate sight setting, but also on the number of guns firing, sequence and rate of fire, it is essential to establish a sequence of ranging giving the greatest economy in firing. The question is complicated by the fact that the number of guns firing, the sequene and rate of fire often react differently on the rate of expenditure of rounds and time used in ranging. Thus increasing the number of guns firing normally speeds up ranging but at the same time increases the expenditure of ammunition; an increase in the rate of fire whilst speeding up ranging demands in some cases a greater expenditure of ammunition and so on.

In addition, the sequence of ranging, to a considerable extent depends on the nature of the target itself. If the observer is given the task of/~~neutralizing~~ destroying a building and the firing is conducted by a large calibre gun and considerable/time is allowed for carrying out the fire task, then the whole ranging must be carried out in such a manner as to ensure the greatest economy of ammunition. But if for example it is necessary to neutralize the fire of a machine gun, which is firing on our infantry then the sequence of ranging will be completely different; it should be based on the economy of time even at the expense of a considerable increase in the expenditure of ammunition. Therefore, it is necessary to view the sequence of ranging given below as a general guide which justifies itself when employed systematically but from which under certain circumstances it is necessary to deviate. It is also necessary to point out that in the case of shooting with a battery it is necessary to eliminate the difference in performance of the guns through selecting guns of like performance for each battery or (in extreme cases) by knowing the degree of difference and allowing for it by individual corrections to the guns.

D.51.

If this requirement is not met it becomes impossible to establish rules for firing guns with varying performances.

Let us consider the sequence of ranging on stationary targets where there is only a small or medium OT angle.

Errors in preparation are such that it cannot be expected that the first round will burst on the line BT, i.e. a burst giving observation for range. In the majority of cases particularly when firing for the first time in a given position the first burst can only be utilized in making corections for line to bring the bursts on to the line of observation. Therefore practising economy in ammunition and time, one should commence firing with a single round.

After obtaining the first sign, the target is bracketted into a '16, 8, 4 or 2 division' bracket, depending on range and the method of preparation.

The repeating of rounds on the extremities of a bracket is only necessary when a short bracket is obtained, i.e. a bracket of two divisions of the sight. For brackets of sixteen, eight and four divisions it is sufficient to have only one sign on each of the ends. Therefore, bracketting a target with an eight division bracket and halving it to a four division bracket must only be done with single rounds, particularly as the probability of obtaining an observation of plus or minus is considerably greater than fifty per cent, even when firing on comparatively narrow targets.

The four division bracket obtained is halved to a two division one. As it is necessary to have not less than two observations for range on each of its extremities, so, in order to economize in time taken for ranging, the halving of a four division bracket must be combined with the repetition of rounds on the extremities and must be carried out, when firing with a single gun, by 2-3 rounds of gunfire, and when shooting with a battery (troop), by one round of troop fire. The same sequence of firing is used also on those occasions when a two division bracket is sought straightaway (i.e. with shortened preparation from the map for ranges of up to three kilometres, and with full preparation with ranges of up to eight kilometres, $B_d < 40$ metres.

Rate of fire must be such as to allow observation of the bursts of each round fired; therefore when firing with a battery (troop), depending on conditions of observation, wind, [redacted], terrain, width of the target, calibre of the gun, etc) the rate of fire should be within the limits of 10 and 30 seconds, after having shot in the battery (troop) the rate of fire for subsequent firing can be changed to the normal rate of 1 - 2 seconds. To achieve this it is necessary to give the order for the new method of fire - "By battery" (troop)!

p.52. Likewise, in firing mortars, fire is carried out with single rounds until a short bracket is obtained. A short bracket is sought and the subsequent firing is conducted in the following manner: in the case of a mortar - 2 - 3 rounds gun fire and in the case of a section or troop - troop fire at a rate which allows for observation of each burst.

In firing on a live moving target, having obtained the direction with a single round the whole of the subsequent ranging is conducted in rounds of gunfire from the battery (troop) until the first bracket is obtained and by single rounds of gunfire for the whole remaining course of the shoot. For economy of time ranging is limited to the bracketting of the target with a four division or an eight division bracket, with an accurate observation on each of the extremities. The bracketting of the target is only carried out in the case of the target moving across open country. In the case of broken country, the approach of the target is awaited with the sights set short.

11. Ranging with a large OT angle.

If a battery is considerably displaced to one side of the line of ob-servation, ranging is considerably complicated and possesses a number of peculiarities set out below.

1. In the case of a large OT angle it is necessary to observe dispersion for line and for range. In connection with this, with targets of the same size, the probability of observing bursts as plusses or minuses falls sharply as displacement increases.

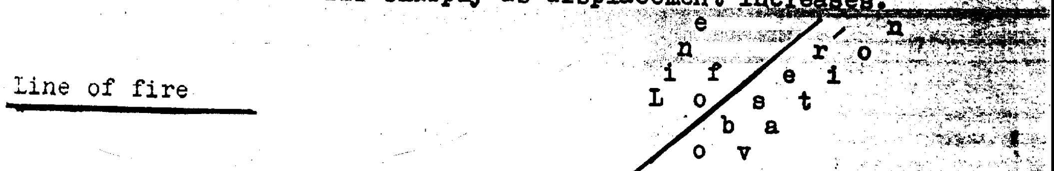

Fig 17. Determination of the size of a medium displacement to the flank when shooting with a large OT angle.
CN=$B6_1$ - medium displacement to the flank from the line of observation.

Let us suppose, (fig 17) that the battery (troop) is displaced to such an extent that the line of observation forms an angle 'α' with the line of fire. If [redacted] is the single of the 100% zone with Bd being half the longitudinal axis and B6 half the lateral axis, [redacted] then the mean deflection from the line of observation will be $B6_1$=CN. As may be seen from the figure, the extent of the mean displacement from the line of observation $B6_1$ under these conditions, i.e. with displacement, is considerably greater than B6. The size of $B6_1$ may be determined by projecting in the direction of CN the deflection B6 and Bd and adding their projections as vector errors.

p.53. Projection Bd on a line CN =

$$CM_1 = Bd \cdot \sin\alpha$$

Projection B6 on a line CN =

$$CL_1 = B6 \cdot \cos\alpha$$

Applying the rule of vector errors running in the same direction, we have:

$$B6_1 = \sqrt{Bd^2 \sin^2\alpha + B6^2 \cos^2\alpha}.$$

Making use of this formula, let us calculate the value of $B6_1$ under the conditions of varying displacement, i.e. with different angles of observation α, with Bd = 20 metres and B6 = 2 metres.

The results of our calculations are given in table 17.

Table 17.

Angle of observation	.
$B6_1$ in metres.	

Table 17 shows the extent to which the lateral dispersal of rounds as it appears to the observer, alters according to the increase in the angle of observation, i.e. with an increase in displacement. But the greater the extent of lateral dispersal of rounds, the smaller will be the number of busrts, in the case of relatively small targets, which will give observation for range. Thus for example if we take the width of the target to be 21 = 10 m and with the mean point of impact being brought accurately on to the line of observation and with the angle of observation α = zero, i.e. with BT shooting, the probability of observing the signs of the bursts (+-) will equal

$$p = \Phi\left(\frac{1}{E6}\right) = \Phi\left(\frac{5}{2}\right) = \Phi(2.5) \approx 0.91$$

With a target of the same dimensions but with an angle of observation α = 5.00, the probability of observing the signs of the bursts (- +) will equal

$$p = \Phi\left(\frac{1}{E6_1}\right) = \Phi\left(\frac{5}{10.1}\right) \approx \Phi(0.5) \approx 0.26.$$

Having calculated the probability of obtaining a sign for the various angles of displacement and assuming the width of the target to be 5, 10 and 20 metres, we will obtain the results shown in table 18.

These results are illustrated in graph form in figure 18 where along the X axis ~~of~~ are laid out the angles of observation and along the Y axis the corresponding probability to these angles of observing the burst. The curve 1 is for a target of 5 metres in ~~width~~ width, the curve II is for a target of 10 metres in width and the curve III is for a target of 20 metres in width.

p.54.

Table 18.

Angle of observation.
Probability of observation of signs of bursts when target width 2 1 = 5 m.
The same when 2 1 = 10 metres.
The same when 2 1 = 20 metres.

From the table and the figure it is seen that with the increase of the angle of observation i.e. with the increase in displacement, the probability of observing the sign of the burst is considerably reduced. As a result of this the expenditure of ammunition on ranging must increase and the whole sequence of ranging must alter.

Fig 18. A graph of the probabilities of observing the sign of the burst under conditions of varying angles of observation and targets of varying width.

I Curve for target of 5 metres in width;
II Curve for target of 10 metres in width;
III Curve for target of 20 metres in width.

2. The second peculiarity in ranging under conditions of considerable displacement, i.e. with a large OT angle, which greatly increase the difficulty, the observer is unable to correct from his observation post the spread of shot according to his troop frontage. In this case as indicated in Section 2 the guns are brought parallel either from another OP nearer to the line BT or from the gun position by means of troop fire with high air burst.

p.55.

3. The usual method of bringing the bursts on to the line of observation employed in the case of small or medium OT angles, cannot be used under the conditions of firing with a large OT angle.

This is explained by the fact that the formula for the calculation of the range coefficient $Ky = \frac{\Delta k}{\Delta 6}$, is approximately correct for a small OT angle, leads to very considerable errors however, when firing with a large OT angle.

In some cases the bringing of bursts on to the line of observation by the normal method, i.e. by altering the setting of the dial sight is impossible. From fig 19 it is evident that in altering the setting of the dial sight one cannot bring the burst p1 on to the line of observation as the burst will move along the arc of the circumference of the range.

In order to bring the bursts on to the line of observation (point P_2) it is necessary to alter the sight setting, as may be seen from the figure.

Fig 19. Bringing the burst on to the line of observation by alteration of the sight setting.

Fig 20. Scale of the range.

The peculiarities enumerated above make it necessary to conduct ranging under conditions of a large OT angle, employing special rules. It has been found in practice that these rules should be brought into use when the correction for displacement is not less than 5-00.

In order to be able to bring the bursts on to the line of observation by means of an alteration in the sight setting it is necessary to know the range scale.

The range ~~scale~~ factor is the angle β (fig 20) expressed in divisions of the dial sight, which is the angle as seen from the observation point of the displacement of the burst from the target, equalling $1\Delta X$.

p.56. The range factor may be determined by means of calculation, from a graph or by ranging. In determining the range factor by calculation the following formula is employed:

From (fig 20) we have - $PA = \Delta X \sin\alpha$ (1)

From pak we have - $PA = \beta \dfrac{\text{Д}k}{1{,}000}$ (2)

Inserting the value PA from formula (2) into formula (1), we get;

$$\beta \frac{\text{Д}k}{1{,}000} = \Delta X \sin\alpha$$

from which;

$$\beta = \frac{\Delta X \cdot 1{,}000 \sin\alpha}{\text{Д}k}$$

If the angle is expressed in divisions of the dial sight then without any significant error we can accept that $1{,}000 \sin\alpha = \alpha$, where α is the correction for displacement, i.e. ПС (PS), then

$$\beta = \frac{\Delta X \cdot \text{ПС}}{\text{Д}k}$$

Normally the range factor is expressed as Мд, then

$$\text{Мд} = \frac{\Delta X \cdot \text{ПС}}{\text{Д}k} \qquad (3)$$

The formula obtained may be used both for the range scale of the sight and for the 'thousandths' scale.

In this formula $\text{Д}k$ and ПС are determined by measurement on the map and the value of ΔX is determined from the range tables in accordance with the range relevant.

For firing with the sight setting set according to the range scale, the formula obtained may be simplified, bearing in mind that ΔX is constant for all ranges.

In order to do this we must divide the denominator and the enumerator by ΔX, we will then have $\dfrac{\text{Д}k}{\Delta X}$ i.e. range of observation expressed in divisions on the sight. Expressing it with $\text{П}k$, we will obtain the required formula as follows;

$$\text{Мд} = \frac{\text{ПС}}{\text{П}K} \qquad (4)$$

If the sight is divided into 'thousandths' (on heavy guns and mortars) it is convenient to calculate the value of Мд which corresponds to the alteration in the range of burst by a 100 metres.

p.54. Then inserting into formula 3,100 metres in place of ΔX, we get,

$$\text{Мд} = \frac{100\,\text{ПС}}{\text{Д}k} = \frac{\text{ПС}}{0{,}01\,\text{Д}k}$$

or, in other words, the range factor for 100 metres ... equal to the correction for displacement, divided by the number of hundreds of metres of the range of observation.

Example: ПС=6.00, Дk = 2,000, then

Md. 600 : 20 = 0.30.

To determine the range factor by means of a graph, one proceeds as follows. On a sheet of paper on the point (target point), the ∠ЦО is constructed (fig 21), equal to the angle formed by the line of the target and the line of observation, i.e. equal to the correction for displacement. From point Ц make an intersection P along the line Ц O on any desired scale, equal to 1ΔX and from this point P drop a perpendicular on to the line Ц K, cutting Ц K at A, and measure it according to the scale on which ЦP is drawn = 1ΔX. It is quite evident that if the line PA is divided by one thousandth of the range of observation, we will obtain an angle under which PA will be visible from the point of observation. As the points A and Ц lie along the same line - the line of observation, then under the same angle PЦ will also be visible from the point of observation, i.e. a line equal to 1ΔX. Consequently the range factor will be

$$Md = \frac{PA}{0.001 Дk}$$

If for some reason, the range factor cannot be worked out prior to firing it is determined during the process of ranging. To this end the following method is adopted. Using the calculated initial settings, the first round is fired and the lateral displacement of the burst from the target is measured in divisions of the dial sight The sight setting is altered in such a way as to bring the second burst as close as possible to the line of observation. After the second round has been fired the bursts displacement from the target is measured. The angle between the bursts is determined to which end the displacement of the two bursts from the target are added together, in the case of the bursts falling on different sides of the line of observation, or the lesser displacement is subtracted from the greater in the event of both bursts being on the same side of the line of observation. Having divided the angle between the p.58 two bursts by the difference in the sight setting for the first and the second rounds the range factor is determined.

In order to determine to which side the sight setting is to be altered it is necessary to take into consideration the position of the gun position, the observation post and the target.

Should the first round be displaced from the target toward the battery position, the sight setting for the second round should be increased; if the displacement for the ~~second~~ first round be in the opposite direction to the battery, the sight setting for the second round should be reduced.

Fig 21. Determining the range factor by means of a diagram.

Example 1.

The battery is to the left of the line of observation; Дk = 3,000 metres. ПС = 6-60; the first round is fired on sight setting 94 (ΔX = 50 metres). Displacement of burst from target: right 45. Determine the correction to the sight for second round.

Solution. We determine the range factor. As in this example firing is being carried out by the range scale (ΔX is constant equal to 50 metres for all ranges) we employ formula (4):

$$Md = \frac{ПС}{Пk} = \frac{660}{60} = 11 \text{ divisions of the dial sight.}$$

As the first burst was displaced in the opposite direction to the battery, the sight setting should be decreased. To determine the correction to the sight divide the size of the displacement by the calculated range; we have: $a = \frac{45}{11} \approx 4$ divisions of the sight.

Example 2. The battery is to the right of the line of observation; Дk = 2,200 metres; ПС = 6-00; ДБ = 4,000 metres. The angle for laying on the thousandths scale is 194. One division of the scale of the sight ΔX = 18 metres. Displacement of the burst from the target: right 30. Determine the correction for the second round.

Solution. We determine the range factor by the formula:

$$\therefore \; M\phi = \frac{\Delta X \cdot \text{IIC}}{\Delta k} = \frac{18 \cdot 600}{2{,}200} = 5 \text{ divisions of the dial sight.}$$

The burst is displaced on the side of the battery, consequently it is necessary to increase the setting of the sight. The correction of the sight =

$$a = \frac{30}{5} = 6 \text{ divisions of the sight.}$$
(in thousandths)

Example 3. The battery is to the left of the line of observation; k = 1,3000 metres, IIC = 5-00; sight setting (on thousandths scale) 120. One division on the scale of the sight, $\Delta X = 16$ metres. Displacement of the first burst from the target: left 40. Determine the correction on the sight for the second round working out the range factor by means of a graph.

Solution. By means of graph determine that the perpendicular PA = 8 metres. Range factor

$$M\phi = \frac{PA}{0{,}01\ \Delta k} = \frac{8}{1{,}3} = 6 \text{ divisions of the dial sight.}$$

It is necessary to raise the sight by

$$\frac{40}{6} = 7 \text{ divisions of the sight.}$$
(in thousandths)

p.59. If there were no dispersal of rounds and the ground surrounding the target were flat, then provided the correction had been accurately worked out, after obtaining the first observation, the second burst would be on the line of observation. However, the dispersal of rounds, the slope of the ground near the target and errors in measuring the displacement from the target of the first burst make it possible that the second burst will not be on the line of observation.

The sight is altered for bringing the next round on to the line of observation only in a case where the correction exceeds 25 metres. If the lateral displacement of the second burst from the target is such that the correction on the sight is less than 25 metres then firing continues without altering the sight setting. This is explained by the fact that the minor displacement of rounds for range is the result of dispersal and making a correction will not bring any benefit while at the same time prolonging ranging.

Firing with a fixed setting of the dial sight, corrections being made on the range sight continues until a clear observation of the sign of burst is obtained (on the line of observation).

Fig 22. movement of the dial sight.

Fig 23. Determination of the movement of the dial sight by means of a diagram.

Having brought the bursts on to the line of observation and having obtained a sign of burst, the target is bracketted for line. (Dial sight bracket). If only the dial sight setting is altered and the range sight setting is not, then as may be seen in fig 22 the burst will be switched from point P_1 to P_2, i.e. will be moved from the line of observation. In order to maintain the burst on the line of observation it is at the same time necessary to alter the range sight setting in accordance with the alteration in range to the extent of P2, P3, while altering the setting of the dial sight by angle β. It is evident that in order to do this it is necessary to know the switch for the dial sight.

p.60. The formula for determining the switch of the dial sight worked out for comparatively small corrections for displacement is not sufficiently accurate when firing with a big OT angle as in this case, and may lead to considerable errors. Therefore when firing with large displacement the switch of the dial sight is usually determined by means of a diagram. The procedure is as follows: on point Ц (point of target) construct angle KЦO (fig 23) = to the angle formed by the line target and the line of observation, i.e. equal to the correction for displacement. From point Ц along the line battery-target, using any scale convenient, the line Ц P equal to 1Δ X. From point P a perpendicular is drawn to the line of observation, cutting it at point Б. The line PБ is measured using the scale employed for drawing ЦP, which was equal to 1Δ X.

It is perfectly evident that if the line PБ is divided by ·001Дб we will then have the switch for the dial sight with the sight setting altered by 1ΔX.

The size of the switch for the dial sight may also be determined by calculation.
In triangle PБШ (fig 23) we have:

$$\text{PБ} = \Delta X \ \text{tg ШС}$$

At the same time we can note the approximate equation

$$\text{PБ} = \frac{\text{Д}6}{1000}\beta$$

where Д6 is the shooting range;
" is the angle through which it is necessary to turn the gun in order to bring the burst over from point Б to point P; consequently β is the switch on the dial sight corresponding to a change on the range sight of 1ΔX.

The right hand parts of the two equations written above are themselves equal, since the left hand parts of the equations are equal. Consequently,

$$\frac{\text{Д}6}{1000}\beta = \Delta X \ \text{tg ШС} \qquad \text{from which,}$$

$$\beta = \text{Шу} = \frac{\Delta X \ \text{tg ШС}}{0.001\,\text{Д}6}$$

The approximated values of the tangents of the angles are shown in Table 19.

Example 1. $\Delta X = 50$ m; ШС = 6-00; tan ШС = 0.7; Д6 = 3,000 m

$$\text{Шу} = \frac{50 \cdot 0,7}{3} \approx 0.12$$

Example 2. In firing from mortars or from guns with the range sight calibrated in thousandths the value of Шу (dial sight switch) is determined on the basis of an alteration in range of 100 metres. The data is the same as for example 1.

$$\text{Шу} = \frac{100 \cdot 0,7}{3} = 0\text{-}23.$$

p.61 The first bracket for line is made equal to one mean error in the determining of direction, i.e. within the limits of 20 and 40 divisions on the dial sight depending on the accuracy of preparation. At the same time, the length of a bracket for line should be such as to include a whole number (sufficiently accurate) of the corrections for the dial sight.

Approximated Values of the angle tangents. Table 19.

Angle in divisions of the dial sight.	Tangents: Exact Value	Tangents: Approx value for Calculations in the field	Angle in divisions of the dial sight	Tangents: Exact Value	Tangents: Approx value for calculations in the field.

Example. Range of observation Дk = 2,200 metres; range Д6 = 3,900 metres; correction for displacement ШС = 6-00; ΔX = 50 metres. Battery is to the left of the line of observation. Let us work out diagrammatically the range factor and the move of the dial sight (fig 24).

$$\text{Мд} = \frac{\text{PA}}{0{,}001\,\text{Д}k} = \frac{29}{2{,}2} \approx 13 \text{ divisions of the dial sight.}$$

$$\text{Шу} = \frac{\text{PБ}}{0{,}001\,\text{Д}6} = \frac{36}{3{,}9} \approx 9 \text{ divisions of the dial sight.}$$

Let us suppose, that after the first round at range sight setting 78 we obtain the observations - left 40.

Correction for the range sight

$$a = \frac{40}{13} \approx 3 \text{ divisions of the range sight.}$$

Fig 24. Determination of Мд and Шу diagrammatically.

After the second round on sight setting 81 a minus is obtained. The battery being to the left of the line of observation, a minus indicates that the line of fire is passing to the right of the target (fig 25). Consequently bracketting the target for line, it is necessary to switch to the left and at the same time to alter the range sight setting. Taking into consideration that the width

of the bracket must be between the limits of 20 and 40 divisions of the dial sight and must contain a whole number of corrections for switch of the dial sight, one must in this case make a bracket equal
p.62 in width either to 9 x 3 = 27 divisions of the dial sight or 9x4= 36 divisions of the dial sight. Bearing in mind that from then on it will be necessary to halve the bracket for line and simultaneously to alter the range sight setting, it is more convenient to take 36 divisions of the dial sight as the width of the bracket.

Having obtained the first bracket for line one halves it, at the same time halving the bracket for range. The width of the last bracket for line when going to fire for effect must be not more than 4 to 6 divisions of the dial sight. After narrowing the bracket to the indicated limits and having gone over to fire for effect, the directional error at the centre point of the bracket will be not be more than two to three divisions of the dial sight (half of the last bracket), which ensures the hitting of the target. When firing on personnel the width of the last bracket for line may be as much as ten to twelve divisions of the dial sight. After going over to fire for effect the directional error at the centre point of this bracket will not exceed five to six divisions of the dial sight; taking into account that the lethal zone for shrapnel (from 30 to 60 metres along the front depending on the calibre of the shell) one may take this error in direction as permissable.

Fig. 25. Bringing the burst on to the line of observation (P_2) and bracketting the target for line.

If as a result of the slope of the ground near the target or for any other reason the bursts, during the process of narrowing the bracket, are dispersed from the target and are not observed, bringing the bursts on to the line of observation is done by altering the range sight setting as was done after the first observation.

In view of the fact that lateral dispersal of rounds is not great it is sufficient to have one clear observation of burst at each end of a line bracket, i.e. it is unnecessary to verify the bracket. One goes over to fire for effect at the centre of the last bracket for line.

Sequence of ranging is as follows: before bracketting the target in the first bracket for line ranging is conducted with single rounds; after the target has been bracketted for line, subsequent ranging is conducted by rounds of troop or section fire, when firing one gun - by gun fire (two rounds) and with compulsory re-laying after each round.

Example. Battery is to the right of the line of observation: Дк = 2,400 metres; Д6 = 5,000 metres; ПС = 6-20; ΔX = 50 metres. Firing is conducted by one gun on the destruction of pillbox. Sight setting 42-80.

We will work out Кф and Шу diagrammatically.

$Кф = \frac{30}{2,4} \approx 12$ divisions of the dial sight;

$Шу = \frac{38}{5} \approx 8$ divisions of the dial sight.

p.63 Sequence of ranging.

No of shot(s)	dial sight	Angle of sight	Range	Observation	Calculations and reasons for corrections.
1	(42-80)	30-00	100	Right 50	50 ÷ 12 = 4 X
2			104	" 4	Range correction less than 25 m. Range setting not changed. Repeat.
3				Left 3-	Target in line bracket 8·4 = 32 divisions of sight
4	+32		108	" 5+	Halve bracket
5-6	-16		106	R5+, L2 +	Halve bracket
7-8	- 8		105	L3 +, +	Halve bracket (1 division of range sight = 4 divisions of A of Sight.)
9-10	- 4	-0-02		R2 -, L5 -	Bracket of four divisions of dial sight obtained.
11-14	+ 2	+0-01			Fire for effect.

In the case of a target on a forward slope or in the event of the observation post being on a considerably higher level than the target ranging with a large OT angle can be conducted without bringing the bursts on to the line of observation. To this end one marks out the line of fire on the ground by firing two rounds on the same line but at different elevations, differing from one another by four to eight ΔX (200 to 400 metres).

The observer mentally connecting the two points of burst by means of a straight line on the ground determines the line of fire in relation to the target. After this bracketting the target for line and the subsequent narrowing of the bracket is done without bringing the bursts on to the line of observation, altering if necessary, the sight setting for range to bring the bursts closer to the target.

In order to bring the following bursts closer to the target, the observer determines from the two initial rounds the approximate range factor and in accordance with it alters the range setting and orders two more rounds gun fire.

Having obtained a bracket for line and an approximate bracket for range, the observer narrows both these brackets, ordering a switch appropriate to the position of the target in relation to the lines of fire as they appeared on the ground, (with the first and second settings of the dial sight). If it is found difficult to determine the switch necessary the bracket obtained for line is halved.

Subsequent narrowing of the bracket for line and the bracket for range, sequence of firing, width of the last bracket and changing to fire for effect are the same as for firing with a large OT angle (see page 62)

p.64 and p.65.

Bursts after order;
Left 0-40, elevation 70,
Two rounds gunfire.

Target

Bursts after order;
Right 0-20; elevation 69;
Fire!

Bursts after order;
Left 0-10; Fire!

Translator's Note: P and small number equals round fired and number; Пр and number equals elevation at which round was fired.

Fig 26. Ranging with a large OT angle at a target situated on the forward slope of a hill. (Battery on the right).

Fig 27. Plan to the example shown in figure 26.

Example (figs 26 and 27). Fire is carried out by a troop of 122 mm howitzers M 1938. The target is a machine gun in an open nest on the forward slope of a hill. The observer decided to carry out his fire task with one gun.

Having had two rounds on the same line but at different elevations 68 and 72 (seventh charge), the observer decided that the line of fire ran to the right of the target, and that also the target was within the bracket 68 - 72, since at elevation 68 he had obtained a minus (burst below the target), and at elevation 72 a plus (burst above the target). Having given the order: "left 0-40, elevation 70, two rounds gunfire", the observer got 'left and plus', namely a bracket for line of 040 and a bracket for range of 68-70. The observer decided to halve both these brackets and therefore ordered; "Right 0-20, elevation 69, Fire!" He observed one right and plus and the other right and minus. The observer decided to conclude the ranging by getting a bracket for line of 0-10 in width by halving the bracket obtained (0-20 divisions of the dial sight) but not to alter the elevation. He ordered; "Left 0-10, Fire!"

The target was now in a "box" of four bursts (5, 6, 7 and 8) and a bracket for line of 0-10 had also been obtained. The observer goes over to fire for effect by ordering: "Right 0-05, Lower Angle of sight 0-04; Four rounds gunfire."

Note: With seventh charge at sight setting (elevation) 72 the angle of elevation is 408 thousandths, on elevation 68 the angle of elevation is 375 thousandths; one division of the range sight corresponds to $\frac{408 - 375}{4} = 8$ divisions of the sight clinometer.

12. Ranging when "firing on oneself" (in the case of the target being between the Observation Post and the gun position.

Preceding paragraphs dealt with ranging under normal conditions of the location of the deployed battery, when the gun position and the observation post are on one side of the target. Under battle conditio situations may arise when the target is found to be between the gun position and the observation post. This happens when fire is directed

p.66 from within the enemy's position; these cases more often occur when the forward edge presents an irregular line. One of the possible variants of such a lay out is given in figure 28.

The preparation of initial settings under these conditions is conducted as a rule from a map using normal methods. In order to construct the formula for the dial sight switch let us look at fig 29 where at points O, Ц and K are shown the respective positions of the gun position and the target and the observation post. From the diagram it is seen that to the observer situated at point K_1 the switch on the dial sight will be the same as for the observer situated at point K, which is on the line of observation but on the other side of the target. Consequently the formula for calculating the switch for the dial sight is $Шy = \frac{ПC}{0{,}01\ 6}$, worked out for the normal position of the observation post and is appropriate for this case also; one should at the same time bear in mind that in the case of the normal position of point ПC - it is the angle between the line gun target and the line of observation, i.e. $ПC = \angle K_1ЦO$; in this case however, as may be seen from the diagram $ПC = 30\text{-}00 - \angle KЦO$.

fig 28. An instance of the target being between the observation post and the gun position.

Fig 29. Correction for displacement ПC and the switch for the dial sight Шy in the case of firing on "oneself".

Rules for ranging relating to the width of the initial bracket, verifying it and narrowing it and choice of settings for going over to fire for effect are the same as in the normal position of the observation post. At the same time depending on the size of ПC, it is necessary to employ either the rules for ranging with a small or medium OT angle or rules for ranging with a large OT angle.

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The location of the observation post on the other side of the target produces peculiarities in determining the sign for correction. While in the case of a normal sighting of the observation post corrections for line and range always have a sign opposite to the one observed, in this case the sign observed and the ones for correction are the same. These situations are explained in figs 30 and 31. In fig 30 it is shown that when a burst is obtained at point P the observer located at point K_1 will observe a displacement of burst to the left at the angle α_1 and must order a switch to the right of angle $\beta = Ky_1 \cdot \alpha_1$. The observer located at point K on the other side of the target will observe the same burst as having a displacement to the right at angle α and must order a switch likewise to the right of angle $\beta = Ky \cdot \alpha$ fig 30.

Fig 30. Bringing the burst on to the line of observation.
Fig 31. Holding the bursts on the line of observation (employment of the switch on the dial sight).

In figure 31 the burst obtained at point P_1 will be given the sign plus by the observer located at point K_1 who will correct it by giving a minus correction of elevation and the observer located at point K on the other side of the target will observe the same burst P1 as minus and will give a minus correction. From fig 31 it is also seen that the switch on the dial sight is always ordered in the direction in which the burst must be displaced from the line of observation when the elevation is altered. Thus for example, having obtained a burst at point P1, the sight setting for range must be reduced. If

the division on the dial sight is not introduced then to the observer located at point K the burst will be displaced to the left of the
p.68. line of observation (P2); as may be seen from the diagram, the correction for the switch on the dial sight must also be made to the left.

Example 1. (Ranging with a small OT factor). The positions of the gun position, the observation post and the target are shown in fig 32; Д6 = 3,600 metres; Дk = 2,200 metres; ПС = 2-80; line of target 38-60; fire is carried out by a troop.

Under these conditions $Ky = \frac{Дk}{Д6} = \frac{2,200}{3,600} = 0,6;$

$$Шy = \frac{ПС}{0,01\ 6} = \frac{280}{36} = 8$$ divisions of the dial sight (by 100 m)

No of shots	Dial sight (Director)	Angle of sight	Elevation	Observations	Calculations of observer and basis for orders.
1	(38-60)	30-00	72	Right 33	33·0,6 = 20 divs on the dial sight
2	+ 0-20			minus	Lower elevation 8 divisions and take into a/c switch for dial sight - 8·4=32 divs of dial st.
3	+ 0-32		64	Left 7 +	Halve bracket Take into a/c displacement L 7
4	- 0-20		68	plus	Halve bracket
5 - 8	- 0-08		70	plus Left 35 Right 3 + Right 2 +	Switch 2nd gun 35·0,6 = 20 divs of dial sight. Verify bracket at elevation 72
9 - 12	2 gun - 0-20) remainder -0-08		72	Plus Right 2 - Right 4 - Right 3 +	Go to fire for effect at 72.

Fig 32. Relating to Example 1, ranging with small OT factor.

Example 2. (Ranging with large OT factor.) Disposition of gun position, observation post and target as shown in fig 33.

Fig 33. Relating to Example 2, ranging with large OT factor.

Д6 = 3,200 metres; Дk = 2,000 metres; ПС = 6-00; ДX = 50 metres; line of target 18-10; firing is conducted with one gun to destroy a strong point. Range factor and switch for the dial sight determined diagrammatically.

$$Mq = \frac{PA}{0,001\,Дk} = \frac{30}{2} = 15$$ divisions on the dial sight;

$$Шy = \frac{PБ}{0,001\,Д6} = \frac{36}{3,2} \approx 11$$ divisions of the dial sight.

p.69.

No of shots	Dial sight (director)	A of S	Elevation	Observation	Calculations of obs and basis for corr.
1.	(18-10)	30-00	61	Left 50	$\frac{50}{Mq} = \frac{50}{15}$=3 divs/elev.
2.			67	plus	Line bracket take 11·2=22divs/dial sight
3 - 4	+ 0-22		69	Left 2 -	Halve bracket.
5 - 6	- 0-11		68	Right 2 +) left 4 +)	Halve bracket.
7 - 8	+ 0-06	+ 0-02		left 7 - right 2 -	Bracket of 6 divs of dial sight obtained Go to fire for effect.
9 - 12	- 0-03	- 0-01			

13. Ricochet Shooting.(Ranging).

When a shell bursts on the ground good fragmentation is obtained if the surface of the soil in the target area is such as to give small cratering. With the increase in the depth of the crater, the effectiveness of the fragments decreases sharply. Completely negligible effect from fragmentation is obtained under conditions of deep snow. It is necessary to bear in mind that when a shell bursts on the ground only open targets are hit. The targets located in trenches, gullies and likewise those behind cover do not sustain any damage from the fragments of a shell bursting on the ground. For the neutralization of such targets it is necessary to employ shell which burst in the air after ricochet.

When meeting an obstacle at a small angle of approach shell ricochet, i.e. are deflected from the surface of the obstacle, which they do not destroy, but only dent slightly. The percentage of shell that ricochet depends on a number of things: type of ground, shape of shell, terminal velocity and angle of strike. All other things being equal the percentage of ricochet is greatest when the angle of strike is smallest. It has been established by trial that at angles of strike not exceeding 15 - 18° on soft and medium ground and angles of 18 -22° on ~~soft~~ hard ground, not less than 80% of shells ricochet. With the increase of the angles of strike the percentage of shell that ricochet falls sharply and therefore, the angles of strike given above are taken as being the limits for ricochet shooting.

The burst of the shell in the air after a ricochet takes place through the action of an exploder (fuze), set for delayed action. The interval and the height of burst of the shell above the ground after
p.70 the ricochet, depend on the time the fuze has been retarded, on the terminal velocity of the shell at the moment of ricochet on the angle of strike and on the type of ground.

The more the fuze has been retarded, the greater will be the interval and the height above ground of the burst after ricochet, as other conditions being equal the interval between the moment of ricochet and the moment of burst is greater.

The greater the final velocity of the shell, the greater the interval and the height of burst above the ground, as during the same interval the shell has time to traverse a greater distance from the point of ricochet.

The smaller the angle of strike the greater the interval of burst; the influence of the angle of strike on the height of burst above the ground is more complicated: on the one hand, with the decreasing of the angle of strike there is a decrease in the angle of deflection which at the same time lessens the height of the burst above the ground on the other hand with a decrease in the angle of strike there is an increase in the interval of burst which brings about an increase in the height of the burst above the ground.

The harder the ground, the greater the interval and the height of burst above the ground.

After a ricochet, the shell usually turns to one side, more often to the right. The angle of turn reaches up to 60°.

The nature of the dispersal of fragments obtained when a shell bursts after ricochet, is shown in fig 34. The greater part of the effective fragments originate from the side walls of the shell and fly sideways, covering a comparatively narrow strip. Measurement of this strip: three to five metres in depth and thirty to fifty metres in length depending on the calibre. The direction of the strip is normally not perpendicular to the line of fire and is governed by the turn of the shell after ricochet.

Commencing ricochet shooting it is necessary first of all to make certain that the angle of descent, which corresponds to the range of firing and the selected charge, gives the necessary angle of strike. At the same time it is necessary to take into account the slope of the ground at the target. In fig 35 the slope of the ground is shown to be towards the battery.

As is seen from the figure, in this case $\theta_c = \mu - a$, where
θ_c - angle of descent;
μ - angle of strike (impact)
a - angle of slope of ground.
In fig 36, the ground is shown sloping away from the battery

In this case $\theta_c = \mu + a$.

Fig 34. Strip of the dispersal of fragments of a shell bursting after ricochet.

Consequently, solving the problem of the possibility of conducting ricochet shooting under these conditions it is necessary first of all to determine the angle of slope of the ground at the target.

p. 71 If the slope of the ground is towards the battery, then one must subtract from the permissible limit of the angle of impact the angle of the slope of the ground; if the slope of the ground is away from the battery, then to the permissible limit of the angle of impact must be added the angle of the slope of the ground. A comparison of the resul obtained with the angle of descent for the particular range will allow one to determine whether it is possible to conduct ricochet shooting, and will give the correct [redacted] choice of charge.

Fig 35. Angle of impact μ with the ground sloping towards the battery θ_c - angle of descent; a - angle of slope of ground.

Fig 36. Angle of impact μ with the ground sloping away from battery: θ_c - angle of descent; a - angle of slope of ground.

Example 1. The ground at the target is sloping towards the battery. Angle of slope $a = 5^o$. Ground at the target - soft. Range 3,400 metres. Troop - 152 mm howitzers M 1938. Choose the smallest charge which will allow ricochet shooting.

We determine the angle of descent which is required under the given conditions to give the required angle of impact. The permissible limit of the angle of impact for soft ground is $\angle \mu = 15^o$. Consequently $\theta_c = \mu - a = 15^o - 5^o = 10^o$.

We choose the smallest charge for which the angle of descent at a range of 3,400 metres does not exceed 10^o.

From the range tables we see:

Table 20.

Charge	Full	1st	2nd	3rd	4th	5th	6th	7th	8th.
θ_c for range of 3,400 metres	$6^o26'$ etc.,								

From table 20 we see that ricochet shooting may be conducted with the following charges: full, first and second. According to the task we choose the smallest, i.e. in this case charge number 2.

p.72 Example 2. Ground at the target horizontal. Remaining conditions the same as in example 1.

Under these conditions the angle of impact = to the angle of descent must not exceed 15^o. Consequently the smallest charge which allows ricochet shooting is charge 5.

Example 3. The ground slopes away from the battery. Angle of slope $a = 5^o$. Remaining conditions the same as in example 1. Under these conditions $\theta_c = \mu + a = 15^o + 5^o = 20^o$.

The smallest charge which allows ricochet [redacted] shooting will be charge No 6.

The rules and the sequence of ranging on ricochets are the same as for normal shooting, when the bursts are on the ground.

Observation of bursts during ranging may be as follows:

a) Smoke of air bursts of shell;
b) Dust and sods thrown up by the splinters.

The most advantageous height of burst above the ground for effective fire, which at the same time allows observation of the sign of bursts are as follows:

76 mm gun.......3 to 6 metres;
107 mm gun......4 to 8 metres;
122 mm how and gun ....5 to 10 metres;
152 mm how and gun/how.6 to 12 metres.

If ~~one is~~ while firing the average height of bursts above the ground exceeds twenty metres, i.e. considerably exceeds the limits indicated the height is reduced, going over to fire with a smaller charge. When going over to firing with a smaller charge, it is necessary to check whether the angle of descent gives the necessary angle of impact.

If after going over to a smaller charge the height of burst above the ground is so great as to make the recognition of signs of burst by smoke impossible and at the same time if the ground at the target is such that the splinters when falling likewise do not give signs of bursts, then it is necessary to go over to normal ground burst ranging, with a fuze set for direct action. The going over to firing for effect in the case where ranging was conducted on ricochet is done according to general rules, that is on the centre of the verified short bracket or on the sight setting on which the verified covering group has been obtained.

If ranging has been conducted with the fuze set for ground bursts and fire for effect is to be conducted on ricochet then the setting of the range sight when going over to fire for effect must be given while taking into account the length of the interval of burst after ricochet.

The basis for this is formed of the following considerations.

After obtaining a short verified bracket by observing ground bursts with limits H and H + 2, the mean of all the possible and at the same time the most probable position of the target, will be, as is known at the centre of the bracket, that is at a point corresponding to the range setting H + 1. If after this when going over to ricochet
p. 73 shooting, the range sight setting is given as H + 1 (fig 37), then the mean trajectory will pass through the centre of the bracket, that is through the point corresponding to the most probable position of the target, but the bursts after ricochet will occur beyond the target to a distance equal to the interval of burst. In order to obtain bursts over the target it is evidently, necessary to reduce the range sight setting by the amount of this interval (~~fig 38~~).

Fig 37. Going over to fire for effect after obtaining a bracket by observation of ground bursts.

The length of the interval of burst as pointed out above increases with the increase of the final velocity of the shell and with a decrease in the angle of impact. In firing guns and howitzers on charges - full, 1st and 2nd, with angles of impact less than 6^{o}, the length of interval of burst exceeds $\frac{1}{2}\Delta X$, reaching up to ΔX. Consequently, when going over to ricochet shooting after ranging by observing ground bursts, the range sight setting used for ranging is reduced by ΔX (50 metres) in the case when the angle of impact is less than 6^{o} and fire from guns and howitzers is conducted with the larger charges. When the angles of impact exceed 6^{o} when firing guns and with any angles of impact when firing howitzers, on small charges the intervals of bursts after ricochet are 10 to 15 metres. Bearing in mind the small length of the interval of burst it is not taken into account when going over to fire for effect and the ranging setting of the range sight is ordered.

14. Upper Register Shooting.

The term upper register shooting signifies shooting at angles of more than 45^{o}.

With such angles of elevation the angles of descent in the vertical plane are greater than 48^{o}. The obtaining of great angles of descent in upper register shooting determines the employment of this type of shooting.

Upper register shooting is used for the following:

a) for the destruction of horizontal coverings;
b) for the striking of targets located behind vertical cover;
c) for the striking of personnel and equipment both in the open and behind cover.

For the destruction of horizontal cover, it is recommended to employ upper register shooting as this gives a big angle of impact and consequently great penetration, with a small possibility of the shell
p.74 ricocheting on impact. This last factor is particularly important when it is desired to destroy concrete structures.

Hitting targets which are behind vertical barriers can only be achieved with steep angles of descent, i.e. by means of upper register shooting.

The employment of upper register shooting for hitting personnel, both in the open and behind cover, is explained by the fact that the splinter action of the shell increases with the increase in the angle of descent.

When a shell bursts, the main bulk of splinters originate from the side walls of the shell. With small angles of descent a proportion of the splinters flying downwards, are stopped by the ground, and consequently do not have any effect; a proportion flying upwards, describe a sharp curve and at the moment of striking lose their killing power and only that proportion of the splinters which flies sidways has killing power. With the increase of the angle of descent, the percentage of non effective splinters decreases, inconnection with which, the depth of effectiveness increases, while the front of effectiveness remains unchanged, not being dependent on the angle of descent.

The most important characteristics of upper register shooting which should be taken into account when solving fire problems, are as follows:

a) the great height of the trajectory and the great length of the time of flight - exceeding thirty seconds; this last characteristic indicates that upper register, should not be employed for hitting fast moving targets, as the great length of the time of flight leads to considerable errors in the calculation of deflection for movement.

b) Very great corrections for drift, many times exceeding the correction for drift for the same ranges when firing with the same gun employing the same shell and charge but when firing at angles less than 45°

Thus, for example, for a 152 mm howitzer M 1938, firing with charge four, at a range of 5,800 metres, at an angle of elevation of lessthan 45°, the correction for drift is seven divisions of the dial sight, but at the same range at an angle of more than 45°, the correction for drift is fifty divisions of the dial sight.

This characteristic points to the necessity of taking the correction for drift into account not only in the case of full but also in the case of shortened and even in the case of preparation of initial data by eye, as ignoring this correction will lead to considerable errors in the preparation of initial settings.

In addition it is necessary to point out the rapid increase in the correction for drift when altering the angle of elevation and connected with this, the alteration in range. While firing at angles of elevation of up to 45° the alteration in range by four hundred metres calls for an alteration in the correction for drift of one and seldom two divisions of the dial sight, in the case of upper register shooting, the same alteration in range of four hundred metres calls for an alteration in the correction for drift of up to ten and more divisions of the dial
p.75 sight, Consequently, with upperregister shooting it is necessary to take into account not only the correction for drift in the case of all forms of preparation, but also to take into account the differences in in the corrections for drift in the course of ranging when going over from one setting of the range sight to another.

a) The dispersal of shell longitudinally with upper register shooting is approximately the same as in the case of shooting at angles of elevation of less than 45°, the ranges being the same. Lateral dispersal with upper register shooting is considerably greater. Thus for example in the case of a 152 mm howitzer M 1938, charge four, range 5,800 metres, angle of elevation less than 45°, the size of B6 = 2.8 metres, while in in the case of upper register shooting, the range being the same, B6 = 9.8 metres, that is 3.5 times greater.

It is quite understandable that likewise the expenditure of shell for targets of a small frontal size will be consierably greater in the case of upper register shooting. Consequently it may be deduced that to resort to upper register shooting for the destruction of small targets is only permissible when this task can not be performed with fire at elevations of less than 45°.

d) The greatest range corresponds to angle of elevation of 45°; deviation from this angle of elevation one way or the other brings about a decrease in range. Consequently in the case of upper register shooting, that is with angles of elevation greater than 45°, an increase in range is attained by decreasing the angle of elevation and a decrease in range by a decrease in the angle of elevation. Therefore, when setting the range sight by the thousandths scale for increasing range it is necessary to decrease the setting of the range sight and for decrease of range one must increase the setting.

e) Correction of the angle of sight to the angle of target has a sign which is the opposite of the sign of the target., that is, when the angle of target is positive (target above the battery) the correction of the angle of sight is negative, and when the angle of target is negative (target below battery) the correction of the angle of sight is positive.

Fig 38. Taking into account the correction to the final elevation by the angle of sight in upper register shooting.

The correction itself is very large and in its complete extent is greater than the angle of target, in other words, in this instance, the correction of the angle of sight to the angle of target covers over the angle of target itself. Consequently, the final angle of elevation in the case of a positive angle of target will be smaller than the table angle for firing, and in the case of a negative one it willbe greater. The reason for this may be clearly understood from a study of fig 38.

p.76 In fact when the table angle of firing α_0, which corresponds to the topographical range to the target, is greater than 45°, then in order that the shell should reach the target A, situated above the level of the battery, it is necessary to lower the line of flight OA_0 corresponding to angle α_0 by an unknown angle y to a position OA; in so doing the trajectory must become flatter.

The charges for our guns are selected on the basis of overlaps for ranges, that is for one and the same range it is possible to employ two sometimes three, or even four charges when employing upper register shooting. In selecting a charge, it is necessary to take into consideration the fire task allotted and the possibility of fulfilling it on each of the respective charges with the least expenditure of ammunition, that is it is necessary to take into account the angle of descent final velocity and the dispersal of rounds.

Example. Shooting is conducted from a 203 mm howitzer B ● with anti-concrete shell to destroy a horizontal concrete erection. Range 10,000 metres. Select the charge.

In the range tables we find that the range of 10,000 metres may be attained employing upperregister shooting using three different charges: the fifth and sixth and seventh, charges.

The basic characteristics of shooting with these charges are as follows (table 21).

Table 21.

Charge	Angle of descent.	Final Velocity m/sec	Bd in m	B6 in m
Fifth	68° 36'	332	33	7,7
Sixth	65° 58'	320	31	7,2
Seventh	59° 29'	303	32	6,9

Comparing the data given we establish the following.

Displacement for range may be taken as being the same for all three charges.

Lateral displacement is somewhat reduced with the reduction in charge; however the difference in the size of B6 is relatively small (approximately 10%) and in this case this need not be taken into account considering the remaining characteristics.

The greatest values for the angles of descent and final velocity we have for charge five. With a reduction in the charge the angle of descent and the final velocity are reduced, and consequently, the penetrating quality of the shell is also reduced. Against the background of these calculations it is logical, so it would appear, to order charge five.

However, in finally selecting the charge it is necessary to take into account one other factor - range in hand with that charge. If the range in question turns out to be close to the minimum limits for the particular charge, to commence firing with this charge is wrong as it may well happen that in the course of ranging or during the subsequent firing for effect that at the upper limit angle of elevation plusses are still being obtained.

"In the example given, the lower range limit for charge five is shown in the range tables as 9,915 metres, consequently the range in hand (85 metres) available when using this charge cannot be considered sufficient, and therefore shooting should be conducted under the circumstances using charge six.

p.77

If for some reason or other the choice of charge is made without the range in hand being taken into account, and a plus is obtained on the upper limit angle of elevation, it is necessary to change to a smaller charge ordering a range sight setting which corresponds to the table range obtained with the former charge. In going over from one charge to the other it is necessary to take into account the difference in drift.

If with the new charge a sign is obtained opposite to the one obtained with the former charge the range sight setting is altered by 2 4 X (100 metres) to obtain a short bracket, irrespective of the method of preparation of initial data or of the width of the bracket sought. This is explained by the fact that the obtaining of different signs on a range sight setting corresponding to the same range but with two different charges indicates inconsiderable displacement of burst from the target.

If with the new charge an observation is obtained of the same sign as previously, then the bracket is sought, with the new charge according to the general rules, depending on the method of preparation.

Both ends of the bracket must definitely be obtained by firing the selfsame charge.

Example. Fire is conducted from a 152 mm howitzer M 1938 for the destruction of a command post. Troop is to the left of the line of observation. Line to the target 45-70; Д6 = 5,900 metres; Дk = 3,000 metres; ПС = 3-60. Metеor and ballistics corrections: range + 100 metres, line + 0-07.

Under these conditions: $Ky = \frac{Дk}{Д6} = \frac{3,000}{5,900} = 0,5.$

$$Шy = \frac{ПС}{0,01\ Д6} = \frac{360}{59} = 6 \text{ divisions of the dial sight (for 100 m).}$$

Corrected range: 5,900 + 100 = 6,000 metres.

In calculating the initial line it is also necessary to take into account the correction for drift, equal to 47 divisions of the dial sight. The initial line will therefore be

(45-70) + (0-07) - (0-47) = 45-30.

We select a charge. It is possible to carry out upper register shooting under the given conditions (Д6 = 6,000 metres) with two charges, the fourth and the fifth.

The general data of shooting with these charges is as follows (tab 22).

Table 22.

Charge	Angle of descent	Final velocity in m/sec	Bд in m	B6 in m	Range in hand
Fourth	66°27'	255	25	9,5	+1430 m - 320 m
Fifth	60°51'	239	28	7,6	+ 630 m -920 m

Taking into account that the dispersion of rounds for charges four and five is apprpximately the same, but the angle of descent and the final velocity are greater, we select charge four for the shoot.

The course of ranging is shown below in table 22a.

Table 22a

No of shot.	Charge	Dial sight A of S (line)		Elevation	Observation	Calculations of observer and reasons for correction
1.	4	(45-30)	30-00	1046	R 25	25·0,5= 12 divs of dial sight.
2.		-0-12			+	Reduce range 200 m. Calculate switch and difference of correction for drift (+0-12)-(0-03) = +0-09
3.		+0-09		1070	+	Impossible to reduce range for this charge by 200 m (limit of range 5,670 m) Change to charge five. Calculate drift difference
4.	5	+0-08		983	-	At 5,800 m we have a + at charge 4 and a - at 5. Try for 100 m bracket. Calculate switch and drift correction.
5 - 6		-0-04		965	+ & L 2 +	Repeat nearest end of bracket.
7 - 8		+0-04		983	- ⊕ R 3 -	Go to fire for effect at centre of bracket.
9 - 12		-0-02		974		

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Chapter II

Fire for effect

15. Problems of artillery fire.

As a rule fire for effect is preceded by preparation and ranging.

In finding an answer to certain fire problems, ranging and fire for effect form two distinct periods often separated one from the other by a considerable interval of time. Thus, for example, when engaging invisible targets, the switching of fire from the datum point to the target sharply divides these two periods; in ranging on the datum point, the observer does no damage whatever to the target, in switching fire on to the invisible target he is in most cases unable to observe the bursts, and in consequence is unable to continue with the ranging.

However, in solving other fire problems, the observer is able to observe and correct his fire up to the very last round. In such cases, ranging not only precedes fire for effect, but also accompanies it. The dividing line between ranging and fire for effect is to a considerable degree obliterated. Each round fired during fire for effect must be utilized to correct the settings and at the same time ranging must be conducted with the object of striking the target during the process of ranging itself. However, even in such a case it is possible to determine the moment when ranging is basically speaking brought to a close and the rate and sequence of fire are altered in the interests of striking the target, at the expense to some extent of observation of bursts. This moment is the change over to fire for effect.

The fundamental tasks of artillery fire are as follows:

(a) destruction;
(b) neutralization, amounting in some cases to destruction of the target;
(c) barrage.

The task allotted, (destruction, neutralization or barrage), predetermines not only the results of the fire, but also the means and method of conducting the fire to attain these results.

p.80 "Destructive fire" is employed in order to render unserviceable various types of defensive works and artificial obstacles.

Destruction as a rule requires ranging to be conducted directly on to the target and requires reliable ground, or in exceptional cases, air observation.

Destructive fire is mainly employed during an advance and in circumstances where the enemy's defence is developed to such a degree and his defensive works so well constructed, that success can not be achieved without destroying the works themselves (concrete emplacements, dug-outs, armoured machine gun nests and observation posts, dug in artillery, barbed wire entanglements and so on).

"Neutralizing fire" has as its task the partial destruction of the enemy personnel strength, denying the enemy full utilization of their armament and the constriction and halting of the enemy's manoeuvres.

The destruction of the enemy's material resources, does not form an independent task but is achieved concommitantly.

Neutralizing fire may be brought to bear on both observed and unobserved targets. Neutralizing fire may be prepared by means of ranging on the target itself or by switching fire on to the target after ranging on any kind of datum or reference point; also by a [illegible] preparation of data.

In neutralizing fire where targets are spread over a large area, the data for firing for effect may be determined by means of shorten[illegible] ranging from the map.

Neutralizing fire is employed in all conditions and in all forms of battle. Neutralization is used against isolated targets and also against limited sectors within the enemy's defence: areas occupied or considered to be occupied by personnel, by weapons or by mechanized units; columns on the move; advancing infantry, cavalry and armoured formations.

"Defensive fire" is conducted with the object of preventing the enemy from occupying or passing through a definite line (area), to restrict movement or to hamper his use of his equipment. Personnel or mechanized equipment which endeavour to penetrate the defensive fire must be covered by fire (neutralized) to such an extent that infantry are able to repel their attack succesfully.

In carrying out defensive fire tasks fire is not directed directly against the personnel and fire resources of the enemy but is brought to bear on limited areas selected with a view to screening the position of our own troops or their advance.

Defensive fire is created by means of laying down stationary (stationary defensive fire - H30) or moving (moving defensive fire - П30), barrages, which are lifted from one line to another in accordance with the movements of our own or the enemy's troops. Barrages may be laid on to visible or invisible areas.

p.81. In defence, defensive fire is employed in the main to screen separate vulnerable or important sectors of the defended area, in the advance it is used mainly for the covering of advancing infantry and tanks from counter attacks and enemy fire.

16. Effectiveness of shooting.

Successful fire for effect is achieved by the following means:
(a) accuracy in determining the settings for firing for effect;
(b) correct choice of shell fuze and charge;*
(c) correct distribution of fire along the front and in depth;
(d) ordering the appropriate method of fire;
(e) creating the necessary density of fire;
(f) careful observation of the results of fire in the case of visible targets and by timely control of fire in the case of invisible targets.

Accuracy in determining settings for fire for effect.

Settings for fire for effect may be determined by the following means: ranging directly on to the target, switching fire from a ranged upon reference point, full or shortened preparation. Each of the enumerated methods is characterized by a definite relative exactness. Thus, for example, after obtaining a short bracket (bracket of 4 Bd) with two observations on each end, the determination of the target may be said to follow the law of Gauss, with the mean error being equal to 1 Bd. The error will be approximately the same in respect of range after ranging on measured deviations. Switching fire from a reference point is accompanied by a mean error for range of from 25 to 100 metres depending on the conditions under which the switch is being made. A full preparation is characterized by a mean error of 1½% of the range and shortened preparation by a mean error of 4% of the range.

In order to compare the various methods of determining the initial settings for effect and to clarify how their accuracy will show up in the results, let us enumerate the above errors in single units of measurement - in sizes of Bd. To this end let us take the range Д = 5 kilometres, and Bd = 25 metres.

Under these conditions the mean error when determining the initial settings for fire for effect will be equal to:
- ranging direct on to the target E = 1 Bd;
- switching fire from reference point E = 1 - 4 Bd; on the average E = 2 Bd;
- with full preparation of initial settings E = 3 Bd;
- with shortened preparation of settings E = 8 Bd

* This question is laid out below when discussing the various types of fire for effect.

p.82 The curves of the determination of the target for range, corresponding to these mean errors and shown in fig 39 clearly illustrate the importance of accurate preparation. To show the influence of the accuracy of determining initial settings on results, let us calculate the probability of hitting a strip twenty metres wide lying perpendicularly across the line battery target, firing on one elevation, corresponding to the centre of the determination of the target.

In view of the fact that the determination of the target and the dispersal of rounds follow the law of Gauss, then in order to determine the probability of hitting the target, let us add the two laws together and we may then consider that the position of the target is determined exactly but that the dispersal of rounds has increased and follows the law of Gauss with a mean error of $Bd^1 = \sqrt{E^2 + Bd^2}$.

Having made the addition we will obtain the following values of $B\phi'$. When ranging directly on to the target

$$B\phi' = \sqrt{(B\phi)^2 + B\phi^2} = B\phi\sqrt{2} = 35 \text{ metres.}$$

When switching from a reference point

$$B\phi' = \sqrt{(2B\phi)^2 + B\phi^2} = B\phi\sqrt{5} = 56 \text{ metres.}$$

When employing full preparation

$$B\phi' = \sqrt{(3B\phi)^2 + B\phi^2} = B\phi\sqrt{10} = 79 \text{ metres.}$$

When employing shortened preparation

$$B\phi' = \sqrt{(8B\phi)^2 + B\phi^2} = B\phi\sqrt{65} = 202 \text{ metres.}$$

Calculating the probabilities of hitting the target with one round, we obtain the following values of probabilities:

$$p_1 = \Phi\left(\frac{10}{35}\right) = \Phi(0,29) = 0,155.$$

$$p_2 = \Phi\left(\frac{10}{56}\right) = \Phi(0,18) = 0,097.$$

$$p_3 = \Phi\left(\frac{10}{79}\right) = \Phi(0,13) = 0,070.$$

$$p_4 = \Phi\left(\frac{10}{202}\right) = \Phi(0,05) = 0,027.$$

Comparing the values obtained of probabilities it becomes evident that it is essential to determine the initial settings for fire for effect as accurately as possible. If in addition to errors
p.84 for range, errors for line are taken into account, then the importance of accurate determination of the settings becomes even greater.

Fig 39.

p.83 Curves of the determination of the target for range, corresponding to the mean errors:-

1. When ranging direct on to the target;
2. When switching fire from a reference point;
3. When employing full preparation;
4. When employing shortened preparation.

p.84 In addition it is necessary to point out that with a sufficiently accurately determination of initial settings (for example when $E = B\phi$) by means of an increase in the number of rounds fired for effect a probability of hitting the target may be obtained which is equal to one.

However, if the initial settings are determined with a considerable error (for example when $E = 8\,B\phi$) then in firing on one setting of the sight the probability of hitting the target cannot be greater than the value determined, irrespective of the amount of ammunition expended. This is explained by the fact that the whole elipse of the dispersion of rounds occupies only a certain portion of the area of the possible positions of the target. Consequently, to obtain a sufficiently accurate shooting, fire would have to be conducted on several settings, covering a considerable area.

Distribution of fire along the front and in depth.

Fire for effect is conducted either with fixed settings of the range sight, clinometer and dial sight or on various settings, that is, covering an area.

In the case of fixed settings for elevation (range sight and clinometer) and direction (dial sight), fire for effect is conducted when targets are of inconsiderable dimensions in both directions (depth and width and height and width), in comparison with the unit elipse of dispersion; when ranging is concluded and fire is conducted with continuous control.

Under these conditions one can be certain of covering the target with a single elipse of dispersion.

To this category belongs destructive fire against such objectives as shelters, machine gun nests, single guns and machine guns standin in the open and so on.

This form of fire is usually more or less protracted, therefore, alterations to the settings during the course of fire for effect on such targets must be looked upon as corrections called for by the altered circumstances which displace the ranged for trajectory from the target.

If fire for effect is conducted under identical conditions of accuracy of ranging and continuity of control but against targets occupying an area, in depth and along the front, exceeding the corr- esponding size elipse of dispersion, then fire is conducted on severa settings of the dial and range sights with the object of hitting the whole area.

If when firing with a troop the dimensions of the target along the front do not correspond to the frontage of the troop, then:

a) against narrow targets (narrower than the troops effective frontage) fire is concentrated according to the width of the target;

p.85 b) Against targets whose width is approximately equal to the effective frontage of the troop - parallel fire;

c) against targets wider than the effective frontage of the troop, equally vulnerable at all points, fire is conducted by distribution according to the width of the target;

d) against broken targets fire is conducted by allocation of individual guns to various points of the target.

If the target ~~whichxpasses~~ is linear and oblique to the line of fire, then in altering the line, the elevation must be altered in accordance with the angle which the target forms with the line of fir

The sequence of the combination of settings of the sights is optional; it is normally dictated by the convenience of conducting the fire.

In all cases when the position of the target is determined insufic- iently correctly, fire for effect is conducted against an area.

To this form of fire belong the following:

a) Fire against invisible targets when the initial settings have been determined either by means of a full preparation or by switching fire from a reference point;

b) Fire on recorded targets when the settings recorded cannot be checked prior to firing and when massed fire or the masking of the target with smoke precludes the possibility of controlling fire;

c) Fire against troops on the move after obtaining a bracket of any width; under these conditions fire is conducted within an area bounded by the limits of the bracket obtained.

"Sequence and type of fire" In firing for effect, depending on the nature of the target and the task, various sequences and different rates of fire are employed.

Typical sequences of fire are as follows:-

Troop a) Methodical fire with one gun, a section or a troop conducted at a rate which allows observation of each burst; this type of fire is employed exclusively when endeavouring to destroy isolated targets, when the results of fire are continuously controlled and on this basis settings are systematically corrected.

b) Gun fire with a given number of rounds to each gun; this type of fire is employed when neutralizing or destroying personnel, observed or invisible from ground observation points, and in all cases where the fire task must be carried out in the shortest possible time.

c) Gun fire without the number of rounds being given to each gun; in defence.

d) Combined fire, that is gunfire alternating with troop fire;

p.86 during troop fire, control is exercised over the results of fire for effect and on this basis corrections to the settings are introduced at the time of going over to gun fire.

Combined type of fire is employed in neutralizing and in destroying observed targets and likewise in laying down defensive fire.

In order that the artillery might, in the limited time allotted to it, fulfil as many fire tasks as possible, each task must be performed in the shortest possible time. However, the rate of fire, on which to a considerable extent, depends the time taken in fulfiling a fire task may only be increased up to a certain limit.

The rate of troop fire is limited by the necessity of observing bursts.

The rate of gun fire depends on the type of gun and is governed by the following: in the case of a short shoot - time necessary to load and lay and in the case of a long shoot - the laid down rate of fire for the particular equipment.

Trials have established the upper limit of rounds to be fired from one gun, when employing full charge; these are shown in the table below (table 23).

Table 23

Time	Number of rounds for one gun							
	76 mm regt gun	76 mm div gun	107 mm gun	122 mm how	152 mm how	122 mm gun	152 mm gun/how	203 mm how
1 minute	15	20	8	8	5	6	4	–
3 minutes	40	40	18	18	12	12	10	3
5 minutes	50	50	25	25	18	18	15	–
10 "	70	60	35	35	25	25	20	6
15 "	90	70	40	45	30	30	25	–
30 "	135	90	55	70	45	45	35	18
1 hour	200	120	80	100	70	70	50	30
2 hours	340	210	140	160	120	120	85	50
3 hours	480	300	200	220	170	170	120	70
6 hours	750	500	300	350	260	260	180	120

In the case of a shoot of a length not indicated in the table the limit of expenditure of rounds is found by interpolation.

P87 In view of the fact that in the case of short shoots the limit of expenditure of rounds for each gun is governed by the time taken in preparation for firing, when firing with smaller charges for periods not longer than ten minutes, the limits of the rate of fire remain the same as for the full charge; when firing for long periods when the limit of expenditure of rounds is governed by the technical considerations of the gun's capacity, the rates of fire for reduced charges are increased in the following manner. When firing for periods of ten minutes or more with the smallest charge for the type of shell used, the permissable rate of fire is increased by fifty per cent; when firing with reduced charges which are intermediate to full charge and smallest charge the limits of expenditure of rounds are also intermediate, roughly proportionate to the number of the charge.

"Density of fire.". The effectiveness of fire for effect may only be achieved if the number of rounds ordered is appropriate to the task in hand. When firing a destructive shoot the mathematical expectation of expenditure of rounds may be easily calculated on the basis of the size of the target, the dispersion of rounds and the necessary number of hits. The actual number of rounds which it will be necessary to expend in fulfilling individual tasks will of course be either more or less than the calculated mathematical expectation of rounds required; however, it will be found that when firing a large number of similar shoots the over expenditure of rounds in one case will be compensated by under expenditure in another.

It is much more difficult to work out the expenditure of rounds in the case of fire for neutralization. Here we have one more factor which does not lend itself to mathematical analysis, namely the morale of the enemy, which depends on a number of factors. The norms of expenditure of rounds in the case of neutralizing fire is calculated on a basis of hitting fifty per cent of the total of the enemy's personnel; it is considered that the remaining unaffected half of the enemy's personnel will be so morally depressed as to be unable to employ its weapons effectively. Battle experience however, shows that in some cases the task of neutralizing has been fulfilled with a considerably smaller expenditure of rounds, while at the same time there have frequent-ly been instances when neutralization could only be achieved after almost completely destroying the enemy.

Therefore, the norms for the expenditure of ammunition for neutralizing fire given in the "Rules for firing" must be looked upon as being only the average, bearing in mind that in some cases there will be deviations to one side or the other.

The effect of neutralizing fire on the enemy's morale depends not only on the total number of rounds fired and the destruction caused but also on the period of time taken to expend these rounds. The sam losses but inflicted during a very short period of time create a far greater moral effect. Therefore, "the Rules for firing" indicate not only the overall expenditure of rounds for neutralizing fire but also the density of fire, that is the number of rounds to be fired in one minute covering an area of one hectare.

p.88. Effective neutralizing fire may only be achieved when the density of fire is sufficient, worked out on the basis of taking all conditions into consideration, including the morale of the enemy.

"Control of the results of fire for effect." The determination of the settings for fire for effect as already indicated above, is accompanied by an error which may be considerable; at best (when ranging directly on to the target) this error will be in the region of 1 Bd, usually it is 2 - 3 Bd and more. Consequently fire on calculated settings will not always be effective.

In addition, in the case of a long shoot there is usually a so-called trajectory shift which is the result of alteration in ballistic and meteorological conditions. Trajectory shift is also observed in the case of short shoots with intensive firing, when conditions [illegible] shooting alter as a result of the heating of the gun.

From all this follows the deduction pointing to the necessity [illegible] observing systematic control over the results of fire for effect [illegible] the periodic introductions of corrections to the settings of the [illegible]

When firing on invisible targets, this does not present any [illegible] difficulty. This matter becomes complicated when fire is [illegible] against targets invisible from the ground. In this case it [illegible] essary to resort to control of fire by means of reference [illegible] ting or to employ special methods of observation (plane, [illegible]

17. Destruction of covered positions (field type).

"Calculation of the number of rounds." The average number of rounds necessary to destroy a machine gun nest, a dug-out, a [illegible] shelter and similar earth-timber structures, depends on the [illegible] a) Size of target; b) range; c) calibre of gun.

With an increase in the size of target the probability of [illegible] the target increases and consequently the expenditure of rounds [illegible]

With an increase in range there is an increase in dispersion [illegible] rounds, and as a result of this there is an increase in the [illegible] expenditure of rounds.

In calculating the probability of hitting a target it is necessary to add to the size of the target an amount all round equal to the radius of the crater, that is to take its extended size; [illegible] it may be seen that a shell which has not hit the target but which [illegible] been displaced from it by a distance less than the radius of the [illegible] may cause the destruction of the target.

Thus the extended area of one and the same target will be [illegible] the greater the radius of the crater, that is the greater the calibre of the gun.

p.89. For example, if the actual dimensions of the target are 2 x 2 [illegible] then the extended dimensions will be: for a 122 mm howitzer

$$(2 + 2)\ (2 + 2) = 4.4 \text{ metres} = 16\ m^2;$$

for a 152 mm howitzer;

$$(2 + 3)\ (2 + 3) = 5.5 \text{ metres} = 25\ m^2.$$

It is quite evident that the probability of hitting the target in the second instance will be greater than in the first provided that Bd as well as Bd are correspondingly equal.

To determine the mean expenditure of rounds, one must know the mathematical expectation of the number of hits to one round into the extended target area.

But the mathematical expectation of the number of hits to one round is numerically equal to the probability of hitting the target.

Consequently, having determined the probability of hitting the extended area of target S, we can easily determine the mean expenditure of ammunition.

Extended area of the target

Actual area of the target

Fig 40. Actual and extended areas of the target.
r = radius of the crater.

For practical calculations, the area of a single elipse of dispersion may be replaced by the area of a rectangle with sides of 2 Bд and 2 B6. Then this area will be equal to 4 Bд · B6 m^2, and the probability of hitting it will be 0.5 · 0.5 = 0.25.

Allowing that the shells will be equally distributed over the area of the single elipse, we have the probability of hitting 1 m^2 of the area

$$P_1 = \frac{0,25}{4B\text{д}\cdot B6} = \frac{1}{16B\text{д}\cdot B6}$$

The probability of hitting the extended area of target S will be S times greater, that is

$$P_s = \frac{S}{16B\text{д}\cdot B6}$$

Consequently, the mathematical expectation of the number of hits - a, on to this area for one round will be numerically equal to the probability, that is

$$a = P_s = \frac{S}{16B\text{д}\cdot B6} \quad \text{hits.}$$

p.90 Having determined the mathematical expectation of the number of hits for one round we will now easily determine the mean number of rounds n_m, which it is necessary to expend in order to carry out the task. In cases where the task is carried out with one round, the mathematical expectation of the number of hits must be equal to one, that is, $a = 1 = np$, from which,

$$n = \frac{1}{P_s} = \frac{16B\text{д}\cdot B6}{S}$$

The formula given for the determination of the mean number of rounds required when firing on medium sized targets may be employed in cases where the task is fulfilled by means of a hit with one round and when ranging is conducted directly on to the target, that is when the mean trajectory passes through the target. If the values Bд and B6 are introduced into the formula (if the target is horizontal) or B8 and B6 (if the target is vertical) for the appropriate calibres firing at a/range and instead of S the size of the extended area of the target for the relevant calibre is taken, we will then obtain the mean expenditure of rounds necessary to fulfil the fire task, the destruction of this target. *

definite

* Rounds expended on ranging are not included in this figure.

For ranges of three kilometres, Bд = approximately twenty metres and B6 approximately two metres.

Substituting these values and the size of the extended area of the target for the letters in the formula, we have

$$n_{122} = \frac{16\cdot 20\cdot 2}{16} = 40 \text{ rounds;}$$

$$n_{152} = \frac{16\cdot 20\cdot 2}{25} = 25 \text{ rounds.}$$

It is necessary, however, to remember that the mean norm given above is in the nature of a guide insofar as it depends on the size of the mean deviations which are always altering and are never known exactly and on the size of the target.

In practice, these figures are used only in calculations when the operation is being planned as a whole. Under these conditions these norms are fully realistic as in cases of mass solution of analogous problems, the inevitable expenditure in some instances will be counterbalanced by an economy in others.

To limit the observer to this mean norm when giving him a destructive fire task would be wrong as the reliability of fire would be become quite inadequate.

p. 91 Reliability of shooting in fulfilling a given fire task is determined by means of the following formula - $r = 1 - (1 - p)^n$.

Where r - is the probability of even one hit (in this case the probability of fulfilling the fire task);

and p - is the probability of hitting with one round, calculated by means of the formula - $p = \frac{S}{16 B\varphi \cdot B6}$

n - is the number of shots.

Substituting the calculated values we obtain when firing a 122 mm howitzer

[redacted] $$p = \frac{S}{16 B\varphi \cdot B6} = \frac{16}{16 \cdot 20 \cdot 2} = \frac{1}{40}$$

$$r = 1 - \left(1 - \frac{1}{40}\right)^{40} = 1 - \left(\frac{39}{40}\right)^{40} = 0{,}63.$$

This reliability of shooting cannot be considered good enough.

In addition, normally for the destruction of a dug out one direct is insufficient, consequently it is accepted that for reliable destruction it is necessary to have two to three direct hits, which in the case of a 122 mm howitzer and 120 mm mortar after completion of ranging will require up to 120 shells (bombs) and in the case of a 152 mm howitzer up to 70 shells (bombs).

The fulfilling of the task with the least possible expenditure of rounds and time is achieved by means of a series of measures. These measures are as follows:

a) limitation of range;
b) detailing for the fulfillment of the task a gun (troop) which is not badly worn;
c) ordering a rate of fire which allows the gun crew to work unhurriedly and therefore to lay accurately;
d) BT shooting which allows accurate ranging for line;
e) observation at close range which permits close following of the results of the shooting and enables one to cease firing as soon as the target is destroyed.

"Carrying out the fire." Fire for destruction of dug outs and shelters is carried out mainly by means of howitzer and mortar batteries. The choice of howitzers for this type of shoot is explained first of all by the fact that the employment of reduced charges gives a steep trajectory and secondly a considerably better explosive action of the shell.

Destruction is attained by means of a shell with a delayed action fuze.

p.92 The successful carrying out of a task is materially influenced by continuous and close observation of the results of each shot and timely correction of the sight settings.

Fire is carried out with a gun or a section; troops are employed only when time is limited and when smoke from the bursts disperses quickly.

Fire is troop fire with an interval between rounds which allows for observation of the result of each shot.

For the first series of troop fire, four rounds per gun is normally ordered, for subsequent ones - from four to eight rounds depending on the corelation of plusses and minuses in the preceding series on the same sight settings; the nearer the corelation of plusses and minuses to equality, the greater the number of rounds ordered for the series.

Corrections of sight settings for each gun are introduced to a degree of accuracy allowed for in the sighting gear.

For convenience in calculation of corrections the observation of each burst should be noted down in a previously prepared pro forma.

Observations are noted for each gun separately with the compulsory consideration of any gun which for one reason or the other has missed its turn.

After each series of troop fire, a total is worked out, the mean point of impact of each gun is worked out in relation to the target, and where necessary the corresponding corrections are ordered.

Example. After the first series of troop fire, the observer, for whom Ky = 0,9 observed

Guns			
1	2	3	4
Left 1 +	Right 1 -	Left 2 +	Right 3 +
Right 2 -	Left 2 -	Left 1 -	Right 1 -
Left 1 -	Right 2 -	Left 2 -	Right 2 -
+	+	Left 3 +	Right 3 -

On the basis of the notes given it is necessary to alter the sight settings in the following manner: first gun remains unchanged; second gun - increase the angle of sight by ½ [redacted] an amount corresponding to ½ division of the range sight; third gun alter for line by 0-02 to the right; fourth gun - alter for line by 0-02 to the left and increase the angle of sight corresponding to ½ division of the range sight.

18. Destruction of barbed wire obstacles.

Destruction of barbed wire obstacles is carried out by 76 mm guns and 122 mm howitzers.

The successful fulfillment of the fire task is materially affected by the relative positions of the gun position, the OP and the target
p.93 (point where breach is to be made). The best conditions are:

a) Range two to three kilometres, as with an increase in range Bd increases;
b) OP in the line gun - target, which allows continuous control over the destruction effected;
c) Line of fire corresponding to the direction of the breach (fire is conducted by means of frontal fire).

"Calculation of rounds required." The expenditure of rounds necessary for making a breach in barbed wire obstacles has been determined by experience.

It has been established that to make a breach of six to eight metres in width, with good observation over the barbed wire obstacle of twenty metres in depth, firing one gun, on the average requires the number of shells (bombs) shown in table 24.

Table 24

Range	Mean expenditure of shell	
	76 mm	122 mm
Up to 3 kilometres	200	85
Up to 4 kilometres	250	140

The average expenditure of 120 mm bombs with the fuze set for fragmentation, to obtain a single breach in a barbed wire obstacle of 20 metres in depth with good observation, using frontal fire, is shown in table 25.

Table 25

Range in metres	Expenditure of bombs
Up to 1,000	40
Up to 2,000	90
Up to 3,000	130

When shooting with a section or a troop, although fire is concentrated, the average expenditure of shell and bombs shown in tables 24 and 25 should be increased by twenty per cent to allow for lateral dispersion, to some extent dispersion for range.

To obtain a breach of double width (12 to 16 metres) according to experience, the expenditure of rounds and bombs should be increased one and a half times.

The expenditure of rounds is governed to some extent by the slope of the ground at the target.

As an example, let us take two instances: 1) the barbed wire obstacle situated on ground which slopes towards the gun position;
p.94. 2) [redacted] situated on ground sloping in the opposite direction. All other things being equal, in the first case the task would have been fulfilled with a smaller expenditure of ammunition than in the second, as in the case of ground sloping towards the gun position, the depth of

dispersion decreases, while in the case of ground sloping in the opposite direction it increases.

The norms given are average ones and should be employed when making calculations in respect of several breaches.

"Conduct of fire". Fire for destruction of barbed wire obstacles requires careful observation over the results of each round and timely correction of sight settings. But, troop fire with a definite interval would considerably lengthen the time taken and therefore in fulfilling the given fire task, combined fire is employed; it is necessary to note down the observations of each burst of a series in troop fire.

Correctness of fire is judged by the resultant destruction and by the distribution of rounds in relation to the forward edge of the wire; rounds falling short must make up from one third to one quarter of all bursts. In this case one must take it that the mean trajectory passes somewhat less than 1 Bd beyond the forward edge of the wire, that is conditions are created for the most advantageous and speedy fulfillment of the fire task.

The average time necessary for effecting a breach in wire (including ranging) is given below (table 26).

Table 26

Range	Average time for the shoot			
	with one gun		with troop or section	
	76mm	122 mm	76 mm	122 mm
Up to 3 kilometres.	Up to 2 hrs.	Up to 1½ hrs.	Up to 1 hr.	Up to 50 min
" " 4 "	" " 2½ "	" " 2½ "	" " 1½ "	" " 1½ hrs

When fulfilling the same task, employing a 120 mm mortar, the following time is taken: range of up to 1 km - 30 minutes; up to 2 km - approximately 1 hour; up to 3 km - 1½ to 2 hours. When firing with a section or a troop the time required decreases by from one and a half to two times.

On the basis of all that has been said, the following deductions may be made:

1) In cases where the time allotted for the destruction of barbed wire obstacles is not limited, it is more advantageous to effect the breaches with fire from single guns (mortars);

2) When it is necessary to shorten the time for the making of breaches, this task is better done with fire from a section or a troop;

p.95 3) When using guns fire is conducted with a reduced charge and when using howitzers with the smallest charge, the object being to obtain the greatest possible angle of descent, giving good fragmentation;

4) In all cases fire should be conducted with a shell, the fuze of which is set for fragmentation.

The experience of the Great Fatherland War has shown that the quickest and most economic destruction of barbed wire obstacles is achieved by means of fire from single guns fired frontally over open sights.

19. Destruction of trenches and communication ways.

Fire for the destruction of trenches and communication ways is conducted as a rule with 122 and 152 mm howitzers.

To give these tasks to batteries equipped with divisional guns is wrong as the explosive action of shell of these calibres is insufficient. Fire is carried out with HE fragmentation shell, with a fuze set for instantaneous or delayed action.

"Calculation of the number of rounds required". The length of the trench is not a constant length, we therefore calculate the expenditure of shell not for the whole length, but per ten metres of trench. The overall expenditure of rounds in each individual case is easy to work out, having multiplied the mean norm in respect of ten metres by the overall length of trench expressed in tens of metres. By experience it has been established that that the burst of a 122mm or a 152mm shell in the trench causes the destruction of that trench over an area equal on the average to five metres.

In our calculations, let us take the following data: width of the trench - 2 metres; length - more than 8 B6; diameter of the crater of a 122 mm shell is 2 metres, and of a 152 mm shell is 3 metres.

Then the extended width of the trench in the case of a 122 mm howitzer will be equal to $2\ell = 2+2 = 4$ metres, and in the case of a 152mm equals $2\ell = 2 + 3 = 5$ metres.

Taking that Bd equals 20 metres, firing at a range of 3 kilometres, we obtain the probability of hitting the target with one round from a 122 mm howitzer:

$$p_{122} = \Phi\left(\frac{1}{Bd}\right) = \Phi\left(\frac{2}{20}\right) = \Phi\,(0{,}1) = 0{,}05;$$

and the probability of hitting the target with one round from a 152 mm howitzer;

$$p_{152} = \Phi\left(\frac{1}{Bd}\right) = \Phi\left(\frac{2{,}5}{20}\right) = \Phi\,(0{,}125) = 0{,}07.$$

The mathematical expectation of the number of hits with one round will be numerically equal to the above.

p.96 The mathematical expectation of the expenditure of rounds for obtaining one hit or in other words the expected mean expenditure of rounds for obtaining one hit will be equal to

$$n_{122} = \frac{1}{p_{122}} = \frac{1}{0{,}05} = 20 \text{ rounds};$$

$$n_{152} = \frac{1}{p_{152}} = \frac{1}{0{,}07} = 14 \text{ rounds}.$$

Expressing it in round figures we have n_{152} = 15 rounds.

But as already stated above, one hit on a trench produces destruction of the trench for a stretch of five metres.

In order to destroy a ten metre stretch of trench, the expenditure of rounds must evidently be twice as great.

Consequently with frontal fire, range approximately 3 kilometres, to destroy ten metres of trench requires on the average 4o 122 mm shells (or 120 mm bombs), and thirty 152 mm shells.

With an increase in range there is an increase in the size of Bd and consequently the probability of obtaining a hit decreases and as a result, the mean expenditure of ammunition increases.

Therefore, when firing at a range of between 5 and 6 kilometres the mean norm of expenditure of ammunition must be increased by one and a half times and when the range exceeds six kilometres ~~they~~ it must be doubled.

In the case of flanking or oblique fire the probability of obtaining a hit increases, and consequently the norm of expenditure of ammunition may be decreased.

The amount by which the norm is altered depends on the angle between the line of fire and the line of the trench and likewise from the relation between Bd and B6.

In each individual case this decrease will be different.

Example 1. The extended width of the trench 2 l = 5 metres; Bd = 20 metres; B6 = 2 metres; the angle between the line of fire and the line of trench α = 60°. Determine the probability of obtaining a hit with one round.

Solution 1. We determine the mean deviation for line perpendicular to the line of the trench

$$Bd' = \sqrt{Bd^2\sin^2\alpha + B6^2\cdot\cos^2\alpha} = \sqrt{20^2\cdot\sin^2 60^\circ + 2^2\cdot\cos^2 60^\circ} = 17 \text{ m}.$$

2. We determine the probability of obtaining a hit with one round:

$$p = \Phi\left(\frac{1}{Bd'}\right) = \Phi\left(\frac{2{,}5}{17}\right) = \Phi\,(0{,}147) = 0{,}08.$$

The probability of obtaining a hit under the same conditions, but with frontal fire, as shown above, equals 0,07.

In this case we have an increase in the probability of obtaining a hit and consequently a decrease in expenditure of ammunition by 14%.

Example 2. Conditions are the same as in example 1, but angle α = 30°. Determine the probability of obtaining a hit.

p.97 Solution.

1) $Bd' \sqrt{Bd^2\cdot\sin^2\alpha + B6^2\cdot\cos^2\alpha} = \sqrt{20^2\cdot\sin^2 30^\circ + 2^2\cdot\cos^2 30^\circ} = 10$ m.

2) $p = \Phi\left(\frac{1}{Bd'}\right) = \Phi\left(\frac{2{,}5}{10}\right) = \Phi\,(0{,}25) = 0{,}13.$

In this case we have an increase in the probability of obtaining a hit and consequently a decrease in the expenditure of ammunition amounting to 50 per cent.

"Conduct of firing". Fire on short trenches should be conducted by means of a single gun or a section.

Fire for destruction against trenches of more than 20 metres in length is conducted with a troop in the interests of speeding up the carrying out of the shoot. In the case of flanking fire, the bursts must be concentrated, in the case of frontal fire the bursts will be spread over the width of the target but in this case the intervals between bursts must not exceed 10 metres. If the troop is given the task of destroying a trench of more than 40 metres in length, then in the case of frontal fire, fire is conducted with two or more settings of the dial sight. Order of fire - combined, that is alternating troop and gun fire; at the same time it is necessary to note down all observations of bursts in the series of troop fire with subsequent corrections of settings for each gun.

20. Destruction of tank obstacles.

The basic anti tank obstacles are various types of dragons teeth, anti tank ditches, banks and mine fields. The destruction of all these obstacles presents artillery with a considerable amount of difficulty and demands an enormous expenditure of ammunition. Therefore, artillery is brought in to fulfill such fire tasks only in cases where there is no possibility of employing any other means of destruction and no possibility exists of overcoming these obstacles.

Dragon's teeth may be of granite, reinforced concrete, timber and iron (steel).

Fire for destruction of dragons teeth is conducted over open sights at close range. For the destruction of granite and reinforced concrete dragon's teeth guns of 45mm to 100 mm calibre are employed. Shell - armour piercing shell.

For destroying wooden dragon's teeth 76 mm guns and 122 mm howitzers are employed, shell - HE fragmentation, with the fuze set for fragmentation action.

Each dragon's tooth in the proposed breach must be destroyed to such an extent that the remaining portion does not present an obstacle to the tank.

Artillery fire for the destruction of iron (steel) dragon's teeth does not give positive results and must not therefore be employed.

For the destruction of anti-tank ditches and banks 122 and 152 mm howitzers and 152 mm gun/howitzers are employed. The fire task consists of destroying the sides of the ditches and banks to an extent which will allow the tank to cross the obstacle without pausing.
p.98 On the basis of this task, for purposes of destruction, it is [illegible] to employ a shell with a fuze set for HE action.

Banks present vertical targets and therefore to destroy them it is necessary to create conditions of fire which allow a flat trajectory and a small dispersion of shell for height. In order to do this it is necessary to fire at the closest possible range with the maximum charge. In destroying anti-tank ditches it is necessary to [illegible] both sides. The most advantageous conditions are those where the size of Bd is the smallest and the angle of descent is between 30 and 45 degrees.

This is achieved by selecting the most suitable charge.

In order to solve the fire task it is necessary to have a comparatively large number of direct hits: not less than from seven to [illegible] in the sides of a bank and not less than 15 to 20 within the extended area of an anti-tank ditch. These demands govern the expenditure of ammunition required for the fulfillment of the task and also the [illegible] of guns employed. The order of conducting fire is the same as for the destruction of trenches.

Fire for creating a breach in anti tank minefields must always be preceded by sapper reconnaisance. The forward edge of the minefield must be pinpointed by the sappers on the ground and must be marked out with aiming points which can be seen by the observer.

A mine may explode under the impact of a direct hit, from the action of blast of a shell exploding either above or close to it or in isolated cases on being struck by a very large fragment.

Basing oneself on the above it is necessary to employ 152 mm [illegible] or gun/howitzers, or if that is impossible 122 mm howitzers. [illegible] of this type have a sufficiently great blast action. Fire for [illegible] must be conducted on ricochets, with the object of employing to the [illegible] advantage the blast at the time of explosion.

The best type of burst in this case is less than when [illegible] ricochet against personnel: for a 122mm howitzer - [illegible] for a 152 mm howitzer 3 to 5 metres.

If the range, the slope of the ground, the surface ground, does not permit the obtaining of ricochets, then upper register shooting is employed, with the fuze set for fragmentation. The characteristi indication of a mine burst is a high, black column of smoke, differir sharply in shape and size from the cloud of a shell burst with a fuze set for fragmentation (fig 41).

Fire for effect must be preceded by reconnaissance fire on the minefield. For this fire is conducted with one gun or with a sectio in jumps of two to three Bd over the whole of suspected depth of the strip. On each of the settings of the sights four to six rounds to each gun are fired at a rate which allows observation of each burst. Exploding mines in the course of this reconnaissance indicate whether the area is mined or not; as to the depth of the minefield, this shooting can not as yet give fully reliable indications in this direction.

p.99 Fire for effect is conducted with a troop concentrated, in jumps of two to three Bd over the whole of the strip. Eight to sixteen rounds to a gun are fired on each sight setting. Combined fire is employed that is, alternating salvos of gun fire and troop fire. An indication of the effectiveness of fire is the explosion of mines simultaneously with shell bursts; towards the end of the shoot, the number of mine explosions decreases sharply.

Fig 41. Explosions of anti tank mines.
Fig 1 and 2 - cloud from burst of anti-tank mine; fig 3- cloud from burst of anti-tank mine, exploded by shell with fuze set for fragmentation.

The absence of mine explosions at the end of the shoot does not give a full guarantee of having obtained a cleared gap; the gap may still contain isolated unexploded mines which must be disarmed by sappers.

By experience it has been established that in order to make a gap in a minefield of fifteen to twenty metres in width and approximately one hundred metres in depth at medium ranges with good observation, and with the ranging completed the following number of rounds are required (table 27).

Table 27.

Type of shoot	Mean expenditure of shell	
	152 mm	122mm
On ricochet	150	300
Upper register, fragmentation fuze	200	400
High trajectory shooting with fragmentation fuze	400	800

21. Destruction of particularly strong structures.

Particularly strong defensive works may be of several different types.

The most important are:

a) Reinforced concrete structures, also called permanent fire points (DOT) (ДОТ);
b) Earth/timber solid structures (DZOT) (ДЗОТ), sometimes strengthened with rails and stone;
c) Armoured turrets and cupolas;
p.100 d) Stone and brick solid structures adapted for defence.

For the destruction of reinforced concrete structures guns are used whose shells on impact with the obstacle possess great striking force (for deep penetration into the concrete) and with sufficient explosive action on bursting.

The destruction of pillboxes (DOT) may be done with either grazing fire against the walls or by high trajectory shooting against the horizontal cover.

Grazing fire is conducted with 122 and 152 mm guns, 152mm howitzers, 152 mm gun/howitzers and 203 mm howitzers.

For upper register fire for the destruction of the horizontal cover of pillboxes 2o3 mm howitzers and 280 mm suppr heavy howitzers are used.

For the destruction of pillboxes, when employing upper register fire, anti-concrete shell are employed with the base fuze set for delayed action.

Depth of penetration into the concrete by a shell of given calibre depends on the final velocity at the time of impact, the angle of impact and the quality of the concrete.

The greater the final velocity, the greater will be the penetrati it may be counted that all other things being equal, penetration wil be in direct proportion to the final velocity. The greater the ang of impact, the greater will be the penetration; thus, for example, penetration of concrete with the angle of impact being equal to 60° two thirds of the depth of penetration when the angle of impact is 9 The smallest permissable angle of impact when firing against concret is 58°. The smaller angles of impact result in ricochets. Depth c penetration into concrete as well as the greatest thickness of wall which can be penetrated by a shell of a given calibre, at various ranges and with different angles of impact, are given in the full artillery tables.

Low trajectory fire against a wall is more effective in comparison with upper register fire against overhead cover. This is explained by the following: while upper register shooting can only be conducte at comparatively long ranges, low trajectory shooting against walls is normally conducted at short range. In connection with this, fire with large charges gives higher final velocity and a large angle of impact, and as a result of this there is great depth of penetration into concrete.

In addition, dispersion of rounds in the case of low trajectory shooting is considerably smaller and thus the expenditure of ammunition and time for the carrying out of the fire task is many times le than with upper register fire against overhead cover.

Thus, for example, when firing a 203 mm howitzer on full charge,
p.101 the values of B• and B6 for various ranges are as follows (table 28)

Table 28.

Range in metres	B• in m.	B6 in m
2,000	0,9	0,8
3,000	1,4	1,2
4,000	2,1	1,6
5,000	2,9	2,0
6,000	3,9	2,4
7,000	5,3	2,8

With upper register shooting with the same howitzer on charge 9, at 7,000 metres, we have Bд = 50 metres; B6 = 5,2 metres.

If the target area with low trajectory fire and upper register fire is the same and we take the range of low trajectory fire as being five kilometres and of upper register fire as being seven kilometres, then the expenditure of rounds for obtaining one hit will be found according to the formula:

for low trajectory fire $N_H = \frac{16 \cdot B\text{•} \cdot B6}{S} = \frac{16 \cdot 2,9 \cdot 2}{S} = \frac{92,8}{S}$

for upper register fire $N_m = \frac{16 \cdot Bд \cdot B6}{S} = \frac{16 \cdot 30 \cdot 5,2}{S} = \frac{2496}{S}$

from which we get $\frac{N_m}{N_H} = \frac{2496}{92,8} = \underline{27}$

Consequently under the conditions given above, the mean expenditure of ammunition for obtaining one hit, when firing in the upper register is approximately twenty seven times greater than with low trajectory fire. In addition under these conditions, the depth of penetration into concrete in the case of low trajectory fire is approximately twice as great as with firing in the upper register.

The figures quoted clearly indicate the great advantage in the destruction of concrete constructions which low trajectory fire against the walls has in comparison with upper register fire. Therefore it is essential to utilize all possible means to employ low trajectory fire for the destruction of pill boxes.

By means of reconnaissance of all types, the following must be ascertained:

a) location of structure, points from which it may be observed and what obstructs observation;

p.102 b) is the structure of reinforced concrete;

c) dimensions and solidity of the structure (thickness of walls and of the overhead cover, existence of armour and its thickness, thickness and nature of material of covering layer against the walls and on the overhead cover);

d) existence of slits, their number and the direction in which they face, disposition of entrances, direction of front;

e) type of structure and its armament (fire point command post and so on);

f) presence and type of camouflage.

In order to hamper reconnaissance, the enemy employs various forms of camouflage; the structure itself is camouflaged as a house, outhouse hummock and so on; to hide it from ground observation various forms of vertical camouflage are employed: bushes, hedges, camouflage nets and so on; slits are covered over with the removal artifical camouflage; dummy pillboxes are erected.

/If /Visual reconnaissance does not indicate whether the structure is a dummy or not; whether it is of reinforced concrete or of timber/earth construction, reconnaissance by fire is carried out. For this purpose 122 or 152 mm howitzers are usually employed; in isolated cases a 203 mm howitzer may be used. Fire is carried out with HE fragmentation shell (fragmentation in the case of the 203 mm howitzer) with the fuze set for instant-areous HE or delayed action. A definite indication of the presence of a reinforced concrete structure is a characteristic pillbox contour, slits, naked concrete. Indirect indications of reinforced concrete in the case of a direct hit are as follows:

a) presence of flames at moment of burst, a wide and low smoke cloud as with fragmentation fuze;

b) a sharp noise of impact different from the sound of burst on normal ground.

The success of a shoot for the destruction of a pillbox is to a large extent assured by the correct sighting of the gun position and the OP. The gun position and the observation post are selected finally after receipt of fire task.

For low trajectory shooting against the pillbox walls the gun position must satisfy the following requirements:

a) the line of fire must be as far as possible perpendicular to the line of the wall to be destroyed; the maximum angle allowed is 4-00;

b) range must be as short as possible; in the case of ranges exceeding four to five kilometres the expenditure of ammunition increases considerably and penetration decreases.

In selecting a gun position for shooting in the upper register one must aim at obtaining the greatest angle of descent (not less than 58°) which will depend on the range coupled with the correct selection of the charge, the greatest final velocity and the least possible dispersion.

p.103 Example. The ground allows a choice of one of two gun positions. Range for first position, 7,400 metres and for the second 9,000 metres. Troop is equipped with 203 mm howitzers B-4.

Employing artillery tables we construct a table of the basic characteristics of fire at these ranges (table 29).

Table 29.

Range in metres	Charge	Θ_c	V_c in m/sec	Bd in m	Bб in m.
7,400	Tenth	59°16'	266	33	5,2
7,400	Ninth	64°24'	280	31	5,3
9,000	Eigth	61°29'	291	32	6,1
9,000	Seventh	65°32'	307	30	6,3

Studying the data contained in this table, the following deductions may be made:

a) For each one of the ranges the greatest charge (charge nine for 7,400 metres and charge seven for 9,000 metres) gives the best conditions for shooting: the greatest angle of descent and great final velocity with dispersion being the same in each case;

b) comparing the shooting on charges seven and nine, preference must be given to charge seven as in this case a somewhat greater angle of descent and considerably greater final velocity are obtained; however a small drawback is an increase in dispersion. Thus under the conditions given the second gun position should be chosen with the range of 9,000 metres and shooting must be carried out on charge seven.

OPs must be chosen as close as possible to the target and as far as possible along the line gun - target.

The Accuracy in ranging and continuous control over the results of each round when firing to destroy pillboxes have a particularly great significance. Ranging is conducted with single rounds from one gun until either a confirmed short bracket or verified covering group are obtained. When firing with a large OT angle, ranging is carried out until a bracket for line of two divisions of the dial sight is obtained. The second gun is ranged after the first gun has completed ranging and is ready to go to fire for effect.

Fire for effect is conducted by means of troop fire at a rate which allows observation of each burst. The introduction of corrections during the process of fire for effect is carried out according to the general rule.

Low trajectory fire against the pillbox walls with the object of obtaining a large final velocity is conducted with first, or in extreme cases, second charge, depending on the thickness of the wall and the range. Low trajectory fire is employed in the instance when the wall of the pillbox rise above the ground by not less than 1,5 metres, one should in this case make certain that fire is being conducted against the wall of the pillbox and not against the wall which screens the embrasure from the front.

p.104 If the wall of the pillbox is protected from the front by a bank, then it is at first necessary to destroy this bank with HE shell. In the case of this bank being of a large size and if it is found impossible to destroy it, one goes over to fire in the upper register for the destruction of the horizontal cover. A pillbox often has a protecting earth covering on top of the main structure. In this case the earth cover must be removed or at least loosened up with HE shell. For this purpose 152 or 203 mm howitzers are employed, depending on the thickness of the earth cover.

Fire for effect is conducted until several shots right through are obtained. An indication of a straight through shot, through the wall or the upper cover cover of the pillbox is smoke issuing slowly from the holes or the embrasures and the muffled sound of the burst.

The mean expected expenditure of ammunition for obtaining one direct hit is determined by the following formula: for low trajectory fire against the pillbox wall - $N = \frac{16\,Bs \cdot B6}{S}$; and for upper register -

$$N = \frac{16\,Bd \cdot B6}{S}$$

In both formulas the value of S is the vulnerable (extended) area of the target.

In determining the value of S in the case of low trajectory fire, from the overall area of the wall one subtracts that part of the area which is formed by the thickness of the horizontal cover and the thickness of the side walls, and in the case of shooting in the upper register, one subtracts from the overall area that part of the area which is formed by the thickness of all walls (front, rear and sides). [illegible] explained by the fact that when the shell hits the reinforced part of the wall it either ricochets, or if it does burst, does not penetrate right through, and in most cases does not destroy the structure.

In addition to the types of fire for pillbox destruction given above fire against embrasure shutters, against the embrasures themselves and against observation slits is employed.

For this purpose guns of comparatively small calibre are used, 57 and 76 mm. This form of fire requires great accuracy and [illegible] action, therefore fire is conducted over open sights with armour piercing shell at short ranges, not exceeding 400 metres for 57 [illegible] and 600 metres for 76 mm guns.

The destruction of armoured ~~turrets~~ cupolas slightly raised above the [illegible] of the overhead cover is attained at the same time as the overhead cover is destroyed by means of fire in the upper register.

Armoured turrets are destroyed by means of fire over open sights. For this purpose the same guns are used as for shooting against embrasures.

p.105 For destroying particularly solid timber/earth pillboxes 152, [illegible] mm howitzers, 280 mm super heavy howitzers, 152 mm gun/howitzers [illegible] heavy mortars are employed.

Shell - HE or fragmentation HE with the fuze set for [illegible] action.

Rules of fire are the same as for the destruction of field works (Section 17).

For the destruction of solid stone and brick buildings adapted for defence, the same methods are used as for the destruction of pillboxes. Destruction may be carried out by means of low trajectory fire, shooting in the upper register or by means of normal fire.

In the case of low trajectory fire concrete piercing shells or [illegible] shell with delayed action fuze are employed.

In the case of shooting in the upper register or normal shooting [illegible] HE shell with delayed action fuze or instantaneous fuze is employed depending on the strength of the overhead cover. Rules for fire are [illegible] general as for pillbox [illegible]

22. Hitting personnel not under cover and open fire points.

Basic conditions for the successful fulfillment of tasks of destroying or neutralizing personnel are:

a) considerable density of fire over a short space of time; the same losses inflicted over a long period of time create a far smaller effect on morale;

b) the elementof surprise of neutralization; a long drawn out sequen of ranging enables the enemy to take advantage of local cover and to put into effect battle dispositions which diminish losses.

Infantry in the open is neutralized (destroyed) mainly by fire from 76 mm guns and 122 mm howitzers as well as by means of 82 and 120 mm mortars. Fire is carried out with a shell with a fragmentation fuze or with a delayed action fuze with the object of obtaining ricochets.

Practice shoots have shown that when firing on one sight setting after completion of ranging, to obtain effective neutralization of well observed infantry or against a fire point in the open at ranges of up to four kilometres, it is necessary to expend on the average the following ammunition:

76 mm	... ...	30 to 35 shells.
122 mm	... ...	20 to 25 shells.
152 mm	... ...	12 to 18 shells.

To carry out this task with the aid of mortars it is necessary to expend on the average the number of bombs shown in table 30 (page 106).

When firing at ranges exceeding four kilometres the expenditure of ammunition is one and a half times greater than that indicated.

If fire is being carried out on several settings of the sight (within the limits of the bracket obtained) then to achieve effective neutral-
p.106 ization it is necessary to expend on each setting of the sight not less than half of the norm given above.

This is explained by the fact that when firing on several settings of the sight (within the limits of the bracket obtained) the norms of expenditure of ammunition must be such as to give the same density of fire over the whole area, bounded by the limits of the bracket, as the density of fire at the target when firing on one sight setting.

Table 30.

Range in metres	Average expenditure of bombs	
	82 mm	120 mm
500	15	-
1,000	20	12 - 15
1,500	30	about 20
2,000	50	25 - 30
3,000	-	50 - 60
Above 3,000	-	75 -120

Fig 42. Density of hits in a strip 1 Bd in width, when shooting to destroy targets in depth by jumps of 2 Bd.

When firing at one range, that is when the target is clearly observed and has been accurately ranged, the mean trajectory passes through the target or close to it and consequently, the number of rounds which fall within the strip of 1 Bd in depth will be equal to 25 of every 100 fired.

If at each range (within the limits of the bracket obtained) the same number of rounds are fired as in the case of shooting at one range, then as may be seen in fig 42 the density of fire will be approximately twice as great as when firing at one range; consequently the norm of rounds at each range may be decreased twofold (halved).

The basic condition for the successful neutralization (destruction) of personnel is considerable density of fire over a short period of time. Consequently the required number of rounds must be fired during a period of two to three minutes which can only be achieved by firing bursts of gunfire of three to six rounds per gun.

p.107 But the personnel will only be neutralized for a limited period of time, and therefore, after neutralization, depending on activity shown by the target, it is either necessary to continue the fire by means of troop fire, or having established observation switch over to carrying out other fire tasks. At the first sign of the target showing any activity, it is necessary to recommence firing with three to six rounds of gunfire.

Fire is as a rule conducted on one setting of the dial and range sights and only in the case when the target has considerable depth or the observation is poor, should fire be conducted on several settings, but ~~with~~

without prolonging the duration of the shoot.

In the process of shooting it is necessary to make use of the observation of the signs of bursts in order to reduce the depth of the area covered by fire.

23. Hitting personnel under cover.

The destruction of personnel in covered trenches can be achieved only by destruction of the cover and at the same time of the trenches themselves. For this reason the norms of expenditure of ammunition and the rules for firing in these conditions are the same as those for the destruction of trenches. (section 19).

When personnel are situated in open trenches, the task of their destruction may be fulfilled either by shooting on ricochet or by shooting with HE instantaneous fuze.

One should make use of shooting with HE instantaneous action only when for some reason shooting on ricochet is impossible. Under these conditions the destruction of personnel is dependent on the destruction of the trenches and consequently the norms of expenditure of ammunition and the rules for firing remain the same as for the destruction of trenches (Section 19).

If because of the conditions of the ground ricochet is possible, then to destroy personnel situated in open trenches it is not necessary to destroy these trenches. The enemy personnel will be neutralized by the shell splinters, the bursts occurring above the trenches after ricochet.

It has been established by trial that to destroy infantry in open trenches at ranges not exceeding three kilometres, after completion of ranging the following amount of ammunition is required on the average for each ten metres of trench:

76 mm	...	...40
122 "	...	...25
152 "	...	...20.

In the case of ranges exceeding three kilometres, as aresult of an increase in the dispersion for range, the expenditure of ammunition increases by one and a half times.

Type of fire employed is combined, with bursts of gun fire alternating with troop fire with 4 - 6 rounds per gun. The rate of troop fire must allow for observation of each burst.

p.108 If the task is to neutralize but not to destroy the enemy the necessity for the complete demolition of the trenches does not arise. The task of neutralization is allotted to troops equipped with 76 mm guns, 122 and 152 mm howitzers and to regimental or heavy mortars. Fire from howitzers and guns, if ground permits, is conducted on ricochet, in the case of mortars, with the fuze set for fragmentation.

If the trenches have overhead cover the 50% of the shell are fired with the fuze set for explosive action.

Neutralization of personnel is achieved by means of bursts of fire lasting from five to ten minutes each. The number of bursts is from two to four. In the intervals between bursts observation is maintained.

By trial it has been established that the following are the norms of expenditure of ammunition (table 31).

Table 31.

Calibre in mm	Number of rounds fired in 1 min for 100 m/trench	
	On bombardment	On harassing fire
76 mm	10 - 12	1 - 2
122 mm	5 - 6	½ - 1
152 mm	3 - 4	½ - 1

Each bombardment commences with a burst of gunfire (2 - 4 rounds), then changes to troop fire with such a rate of fire as to ensure that the number of rounds allotted for the bombardment is expended in the time given.

In the course of the harassing and troop fire during the bombardment the results of the observation of bursts for each gun are recorded and on the basis of calculations, corrections are introduced to the settings of the sighting gear, accurate to one division of the dial sight and range sight (sight clinometer).

24. Neutralization of personnel on the move.

Depending on the character of the moving target, the speed of movement, nature of ground and also on the time available and the feasibility of preparation, various methods of fire are employed for hitting such targets.

A fundamental condition for successfully striking moving targets is the ability to bring down heavy fire over a short period of time as far as possible with the element of surprise. When time is available and information can be obtained regarding the direction and the area of the proposed movement of the target, preparations are made in advance, and the shoot posseses the characteristics of a barrage between definite lines. Defensive fire is caried out usually on a comparatively wide front; in certain cases however, defensive fire is put down on narrow sectors, which the enemy cannot mine on the move.

The drill for bringing down defensive fire, is laid down in sections 25 and 26.

Let us take a shoot for the striking of targets which are moving in an area where defensive fire has not been prepared. For shooting at moving infantry, cavalry and motor cyclists the 76 mm gun, 122 and 152 mm howitzers and the 152 gun/howitzer are used. Fire is carried out with the HE fragmentation shell with the fuze set for fragmentation action; if the ground at the target and the angle of impact permit the obtaining of ricochet, then the fuze is set for delayed action, but if these condition does not exist then the fuze is set for fragmentation action.

In the case of the fuze set for fragmentation, shooting is carried out with the smallest charge for the particular range with the object of obtaining the best fragmentation action. Shooting is as a rule conducted with a troop, the troop frontage of shell corresponding to the width of the target.

In the case of targets moving on a wide front fire is carried out with the guns concentrated to the effective lethal radius of the shell.

The method of conducting fire for effect depends on the speed of movement of the target.

In firing at slow moving targets (mainly infantry) ranging is carried out directly on to the target bracketting the target into four or an eight division bracket. At the same time in order to economise in time it is permissible to limit oneself to obtaining one accurate observation on each extremity of the bracket.

Change to fire for effect is introduced either on one of the range sight settings within the limits of the bracket or on the extremity of the bracket towards which the target is moving, depending on the speed of movement of the target. Gun fire is used 2 - 4 rounds per gun being ordered.

As soon as infantry begin to move out of the effective zone of fire the range and dial sight settings are altered in jumps in the direction of the movement of the target: range sight in jumps of one to two divisions (50 - 100 metres) and dial sight - depending on the speed of movement and direction of the target.

In the case of comparatively fast moving targets (10 - 40 kilometres an hour) it is not possible to employ the method of fire for effect given above as during the period of time required to obtain a bracket and the going over to fire for effect the target will have had time to move a considerable distance and as a result of this the observations obtained lose their value. Therefore, for hitting moving motor cyclists and cavalry ranging is carried out not on the target but onto a line located alon the line of movement of the target.

At the target's approach to the line ranged upon gunfire is ordered, 4 rounds per gun. The order "Fire!" is given bearing in mind the speed of movement of the target and the time of flight of the shell, with the object of obtaining the first burst at the moment of the target crossing the line.

p.110 Subsequent shooting is carried out with jumps of two to four divisions of the range sight in the direction of movement of the target (100 - 200 metres for guns with sights graduated in thousandths), introducing if necessary a correction to the dial sight setting.

Each pause in the movement of the target even a short one must be exploited for increasing the rate of fire and for obtaining greater accuracy in the firing data.

25. Fixed defensive fire (NZO - HZO).

Fixed defensive fire is employed: in defense for repelling an advancing enemy on previously determined lines and in the advance - for covering own advancing infantry from counter attacks and fire. Sectors for defensive fire are selected on the most important lines within the enemy's defence as well as in the immediate vicinity of one's own troops. The distance between the nearest edge of the sector of defensive fire from one's own infantry must be such as to ensure that the infantry does not suffer casualties from the fire of one's own artillery. In defence the infantry as a rule is entrenched and is protected from fragments.

Therefore the minimum safe distance of the line of defensive fire must safeguard own troops only from direct hits on the trenches by isolated shells deflected as a result of dispersion. This requirement is satisfied by a distance of 200 metres in the case of frontal fire and 100 m in the case of flanking fire.

In the advance when our own infantry is not behind cover, they must be protected against fragments of our own shells: consequently the safe distance in this case is laid down as 400 metres. This may be reduced to 200 metres in the case of flanking fire on condition that fire is conducted with shell with fuzes set for HE action.

The sectors of defensive fire must be under observation.

The width of the sector of defensive fire is established in accordance with the front of the effective lethal area of the shell. The following norms of the width of the sectors for four gun troops of various calibres are given.

76 mm troop	... ...	up to 100 metres.
107 mm troop	... ...	up to 150 metres.
122 mm troop	... ...	up to 200 metres.
152 mm troop	... ...	up to 250 metres.

A troop consisting of six 120 mm mortars is given a sector of 300 m in width. A section consisting of three 82 mm mortars can lay down a sationary defensive fire along a front of up to 90 metres, a company of three platoons (sections) - on a front of 250 to 300 metres.

In the case of flanking fire, for the depth of the sector of the defensive fire, the same norms are employed as for the width of the sector in the case of frontal fire.

The initial settings for the laying down of fixed defensive fire are determined as follows:

a) By ranging directly on to the area selected for the defensive fire;
b) By calculating the switch from a line already ranged on;
c) By calculations based on the data determined by the ranging gun.

p.111 The settings for conducting fixed defensive fire in close proximity to our own infantry must be determined by means of ranging.

In the case of other sectors, the settings calculated on the basis of switching fire from a line or on the basis of utilizing data produced by the ranging gun must be checked at the first possible opportunity by the basic gun with single rounds.

Calculated or ranged settings must be periodically corrected in accordance with any alterations in the meteorological conditions.

An extremely important factor governing the success of defensive fire is the ability to bring down such fire at the right moment.

With this aim in view the following measures must be taken:

a) Note down the initial settings on the guns' shields, indicating the name of the sector of the defensive fire and the signal calling for such fire;
b) Prepare the ammunition, laying it out near the guns;
c) During the intervals between firing lay the guns on the settings noted down in order to be able to bring down defensive fire on the most important sector;
d) Cease the carrying out of the task previously allotted on receipt of the signal calling for defensive fire;
e) Maintain a twenty four hour duty roster of gun numbers to produce immediately the first salvo;
f) Open fire by ordering only the name of the sector without giving the settings.

Provided all these measures are carried out fire may be opened within twenty to thirty seconds of being called for.

In the case of frontal fire, firing is conducted with an effective front on one setting of the range and dial sights. During the first moment fire must be of such a power as to halt the enemy infantry and force them to take cover. With this end in view fire is commenced with a burst of rapid fire of two to four rounds pergun followed by eight rounds gunfire after five seconds interval in the 76 and 107 mm guns and four rounds gunfire with ten seconds interval in the case of 122 and 152 mm guns. Subsequent firing depends on results:

a) Repeat if necessary on the same settings;
b) Continue firing on the infantry lying down;
c) Switch fire in accordance with the movement of the enemy forward or backwards;
d) Cease firing.

If ground conditions permit, defensive fire should be conducted on ricochet. If ricochet firing is impossible then defensive fire is conducted with HE fragmentation shell, fuzes set for fragmentation.

In the case of flanking fire the defensive fire sectors for troops are sub divided as in the case of frontal fire, each troop covers the
p.112 whole depth of the sector allotted to it. In order that in this case also fire may be conducted without altering the settings, each troop fires with sections concentrated, 1 Δ X (50 metres) in the case of 76 and 107 mm guns and 2 Δ X (100 metres) in the case of 122 and 152 mm guns and howitzers. Sections open fire simultaneously and fire on one setting. The norms of expenditure of ammunition and sequence of fire are the same as for frontal fire.

26. Movable Defensive Fire. (PZO - II30)

In order to repel tank attacks movable defensive fire is employed consisting of barrages on previously marked out lines moving according to the movements of the tanks. The bounds are selected across tank approaches and must if possible be under observation. The distance between bounds must be such as to allow artillery to switch fire from one bound to another after the passage of the tanks through the first barrage Consequently the distance between bounds is determined by the time necessary to switch the fire and by the speed of the tanks during the attack. Settings for firing on each of the bounds must be determined beforehand, passed on to the guns and there noted down. In order to save time when ordering a switch to a new bound only the name of the new bound is ordered. The total time, made up of the time necessary to pass the order, to fulfill this order and the time of flight will be in the region of from one to one and a half minutes, depending on the efficiency of the troop. The speed of the tanks in attack, from wartime experience is taken to vary from 12 to 25 kilometres per hour. Consequently in one minute the tanks will traverse from 200 to 400 metres and in one and a half minutes from 300 to 600 metres. Therefore the distance between bounds must be between 300 and 500 metres. The last bound lying nearest to our own troops is 300 to 400 metres from the forward edge.

The norms of the width of troop sectors laid down for fixed defensive fire do not apply in this case. This is explained by the fact that the width of a fixed defensive fire sector is determined by the front of the effective burst of the shell. In the case of a moving defensive fire task, the fire is not directed so much against personnel as against tanks. As is known, fragments because of their irregular form quickly lose their velocity and consequently their lethal action. In addition in this case neutralization can only be achieved by means of large fragments. Therefore the width of the sector in the case of stationary defensive fire must be reduced as experience shows by approximately two to two and a half times.

For 3-troop batteries depending on the calibre of the guns, the following norms of sector width are established: 300 metres for a battery
113 equipped with 152 mm guns or howitzers or gun/hows; 250 metres for a battery equipped with 122 mm weapons; 180 metres for a battery equipped with 76 mm guns.

The sector is sub divided into three ordinary troop sectors. On the more important sectors the fire of sometimes two and sometimes three batteries is doubled up.

The initial settings for carrying out a movable defensive fire task are determined as follows:

a) by ranging directly on to the sectors on each bound;
b) calculating the switch from a line already ranged upon;
c) calculations based on the data obtained by the ranging gun.

If ranging on each sector is impossible, it is desirable to check the calculated data by single rounds. Ranged for or calculated data must be periodically corrected in accordance with any alterations in meteorological conditions.

Fire for effect is carried out with HE shells, fuzes set for fragmentation.

Defensive fire on each bound is brought down simultaneously by all troops on order from the battery commander, with the object of obtaining the first bursts at the moment of the leading tank's approach to the bound. Fire is conducted on fixed settings of the range and dial sights by means of bursts of gun fire at maximum rate up to the time of the tanks issuing forth from the zone of fire, after which fire is switched to a new bound.

If the direction of the movement of the tanks or the width of the strip occupied by them does not fully correspond with the anticipated direction and the strip which is covered by the sectors of moving defensive fire of the battery, then the troop commanders switch their fire independently or on orders from the battery commander, who orders a correction for line for all troops. Defensive fire bounds and calculated range remain the same.

Simultaneously with the moving defensive fire whose main objective is the repelling of the tank attack, fire must be brought to bear again the infantry, who are moving with and directly behind the tanks. The task of this fire is to part the infantry from the tanks before the latter reach the last bound. For the carrying out of this task mortar or 76 mm troops are used, which fire according to the rules laid down for fixed defensive fire, on the same bounds. Fire is continued for two or three minutes on each of the bounds after the battery conducting the moving defensive fire has switched to a new bound. On the last bound after the tanks have issued from the zone of fire, all troops continue to fire on the same settings to repel the infantry attack. Those tanks which have succeeded in breaking through the last bound of the moving defensive fire are engaged by guns of the anti tank defence.

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CHAPTER III

SHOOTING UNDER SPECIAL CONDITIONS.

27. Peculiarities of shooting in the mountains.

The peculiarities which may be found under conditions of shooting in mountainous country are brought about by the following circumstances:
a) Broken nature of the country in the immediate vicinity of the target
b) Considerable differences in the respective heights of targets, guns and OP's;
c) Rarified atmosphere at high altitudes;
d) Rapid change in meteerological conditions during the flight of shell

Because of this, shooting in the mountains requires the application of certain rules appropriate to the conditions of each individual shoot.

However, these conditions are so varied that to give definite rules for each individual case is impossible. It is only possible to give rules governing the more typical forms of terrain and interrelationship between target, gun position and OP.

These typical cases are as follows:
1. Target situated on level ground with:
   a) OP - on the same level as target or slightly above it.
   b) Height of OP above target is considerable.
2. Target situated ona slope.
3. Ground in target area broken to a considerable degree.

Each one of these cases introduces a characteristic peculiarity into conditions of shooting which are analysed below.

28. Topographical peculiarities of preparation for firing in mountains

The peculiarities of preparation for firing under mountainous conditions are brought about mainly by the fact that gun positions, OP's and targets are at different levels, the difference is very often considerable. When the steepness of slopes is considerable and the intersection of horizontals is also at a great height, estimation of height from the map becomes unreliable. In most cases it is only possible to hit targets when firing with guns with a sufficiently high trajectory. Guns with a flat trajectory are of little use when firing in mountains.

All this brings us to the necessity of :
1. Determining the height interrelationship of the OP, gun position and the targets employing special instruments;
2. In determining corrections for displacement it is necessary to fix a base to the horizon;
3. It is essential to take into consideration the correction of the angle of sight to the range angle;
4. When firing over crests and summits the determining beforehand the possibility of striking the targets.

1. 'Determination of interrelationship of height' when it is impossible to use a map, special instruments are employed.

In using the artillery instruments (stereo-telescope and the director the angle of target and of the basic gun are measured from the OP. Knowing the range Дk and base Б, the relative height of the target and the pivot gun in relation to the OP are worked out, to which end the angle of target is multiplied by one thousandth Дk, and angle of the pivot gun by one thousandth Б. Having thus determined the height of the target and gun position in relation to the OP it is not difficult to determine the height of the target in relation to the gun position and knowing the range Дб, to calculate the angle of target from the gun position. It is necessary of course to take into consideration the fact as to whether the angle of sight is one of elevation or depression

In the event of the angle of target and the angle of pivot gun from the OP (more than 0-20)being considerable, it is necessary to add to th calculated difference one twentieth of the value of the angle, since, a is well known, one division of the dial sight does not correspond to one thousandth, but to one nine hundred and fifty-fifth of the range.
1/1,000 1/955

Example; δ = 1,200 metres; $Дk$ = 2,600 metres. From the OP, the following are measured, the vertical angle to the target (angle of tgt and $M_{ц}$ = +0-40 and the vertical angle to the pivot gun (angle of basi gun) $M_{б}$ = -2-40.

We determine the height in relation to the OP.

a) Target: $+40 \cdot 3{,}6 = +144$; $+144 + \frac{144}{20} = +151$ metres.

b) Pivot gun; $-240 \cdot 1{,}2 = -288$; $-288 - \frac{288}{20} = -302$ metres.

Consequently, the difference in height of the target over the pivot gun is equal to

$$+151 - (-302) = +453 \text{ metres.}$$

If the pivot gun is not visible from the OP we may then proceed in two ways:

1) Choose an intermediate point from which both the OP and the pivot gun are visible and determine their difference in height in relation
p.116 to the intermediate point by the same method,

2) Employ an aneroid barometer.

Employing an aneroid barometer, the difference in height is determined by the difference in pressure.

To do this one either employs two calibrated barometers keeping one at the OI and the other at the gun position, or one uses one barometer taking it from the gun position to the OP or back again.

At both these points the barometrical readings are taken to an accuracy of one milimetre, and the laid down corrections are introduced into the readings. In the event of considerable differences in height in addition, the temperature of the air is measured by means of a sling thermometer. The rules for measuring the pressure with the aid of a barometer and the air temperature with the aid of a sling thermometer are given in the handbooks dealing with ~~with~~ the artillery meteorological service.

It is well known that as one ascends, whether by plane, by balloon or simply by climbing a hill, the barometric pressure decreases in so constant a manner that by the extent of this decrease altitude may be determined.

It may be taken that for every ten metres increase in altitude, the barometric pressure decreases by one milimetre. However, one may only use this ratio to determine differences in height when differences in pressure are inconsiderable - not more than four to five milimetres.

Sufficiently accurate results are obtained if the so-called "barometric steps" are employed.

This barometric ladder is a name given to the height to which one must ascend to obtain a decrease in pressure of one milimetre under given meteorological conditions.

The barometric ladder depends on the air temperature and on barometric pressure itself and consequently on the height of the point above sea level and on the weather.

In table 32 is given a part of the table of the barometric ladder which is to be found in the mountain artillery tables.

In order to find the barometric ladder with the aid of this table it is necessary to take the mean pressure and temperature lying between the lower and the upper points.

"The extent to which one point is higher than another is equal to the difference in pressure at these two points, multiplied by the barometric ladder. That point is highest where the pressure is lowest."

Example: The following measurements are obtained at the OP:

pressure $H_{НП}$ = 588 mm, temperature $t^{o}_{НП} = +10^{o}$;

at the gun position; pressure $H_{ОП}$ = 644 mm, temperature $t^{o}_{ОП} = +16^{o}$.

We determine the mean pressure and temperature:

$$H_{cp} = \frac{588 + 644}{2} = 616$$

$$t^{o}_{cp} = \frac{+10 + 16}{2} = +13^{o}$$

BAROMETRIC LADDER

Table 32.

Temperature

"At the side is given pressure in mm." Translator's note.

p.118. From mean pressure and temperature we find the barometric step from the tables. In this case it is equal to 13.7 metres.

We determine the difference in pressure between the OP and the gun position: 644 – 588 = 56 mm.

We multiply the difference in pressure by the barometric step and we obtain the difference in height: $56 \cdot 13,7 = 767$ metres.

As the pressure at the OP is less, the OP is higher than the gun position (by 767 metres).

2. 'Projection of the measured base to the horizon' is carried out in cases where the vertical to the pivot gun, measured from the OP exceeds 5-00. If projection of the base to the horizon is not carried out then corrections for displacement will be accompanied by a considerable error.

Projection of the base to the horizon consists of correcting the base by the angle of slope, that is in determining the base's horizontal projection as a base measured on the ground possessing a considerable slope may differ widely from the size of its projection.

The horizontal projection of the base is normally determined by means of a right-angled triangle by the formula $Б_П = Б \sin(15\text{-}00 - М_6)$
where $Б_П$ is the projected base, that is the horizontal projection of the measured base
$Б$ is the sloping base measured on the ground
$М_6$ is the angle to the pivot gun measured from the OP.

If the angle $М_6$ does not exceed 5-00 then the sine of the angle necessary to make up 15-00 will be close to unity and therefore it will not be necessary to project the base to the horizon.

The sine of the angle necessary to make up 15-00 to the angle $М_6$ is determined by the normal abridged sine table.

<u>Example.</u> $Д_k$ = 3,100 metres; $Б$ = 1,250 metres; angle $М_6$ = 6-00; figure by the pivot gun = 4-00; we project to the horizon:.

$Б_П$ = 1250·sin(15-00 – 6-00) = 1250·sin 9-00 = 1250·0,8 = 1,000 m

We determine the discrepancy d = 1,000·sin(15-00 – 4-00) = 1000·0,9 = 900 m.

Then $Д_6$ = 3,100 + 900 = 4,000 metres.

Correction for displacement $ПС = \frac{1,000 \cdot 0,4}{4} = 1\text{-}00$

Corrections for elevation (range angle of elevation plus angle of sight) for 76 mm mountain gun, long range shell, target being higher than the battery. Table 33.

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p.120. If the base is not projected to the horizon, we obtain:

d = 1,250·0,9 = 1,125 metres;
$Д_6$ = 3,100 + 1,125 = 4,425 metres;
$ПС = \frac{1,250 \cdot 0,4}{4,2} = 1,19.$

Then, the error in the determination of $Д_6$ will be 225 metres = 4½ divisions of the sight and the error in the calculation for line will be 0-19.

3. 'When correcting the [redacted] angle of elevation and turning it into the final angle to the target' we must take into account that in present day tables these corrections are worked out exactly without any allowances for the parabollic form of the trajectory and thus they are different for the different guns, shells and charges.

For a given gun shell and charge it is most advisable to [redacted] correlate these corrections with the angle to the target beforehand and to make up a table of the correlated corrections based on range and the difference in height of the target from the gun. These correlated corrections will be in actual fact corrections for angle of sight, if one takes the basic settings for the angle of sight as being 30-00. Such tables are given in the mountain range tables. A part of these tables pertaining to the long range shell for the 76 mm mountain gun is given in table 33 (see page 119). This table is very easy to use.

<u>Example.</u> A 76 mm mountain gun is firing a long range shell; $Д_6$ = 5,900 metres; the height of the target above the gun is equal to +350 m. From the tables we find the correction for the angle of sight is 63 divisions of the sight, therefore the setting of the angle of sight will be 30-63.

4. 'The ability to fire over high crests (summits)', when these are situated between the gun position and the target is determined by the aid of tables of trajectory ordinates to be found in the mountain range tables. For each trajectory, the ordinates are given for ranges from the gun in divisions of two hundred metres (Table 34).

Table 34

76 mm Mountain gun, Long range shell.

Crest Range from the gun → Distance of flight (Range to target) ↓	2,200	2,400	2,600	2,800	3,000
	Ordinates in metres				
3,000	95	78	57	31	0
5,000	374	383	387	390	385

If the target and the gun position ara roughly on the same level, then one first of all finds out whether or not there is a crest between the gun position and the target, the height of which above the gun exceeds the full height of the trajectory. It is quite understandable that should such a crest exist, shooting from that particular gun position is not possible. However, when the height of the trajectory exceeds the height of the crest lying between the gun position and the target this
p.121 does not mean that it is possible to hit the target as one of the crests may be higher than the corresponding ordinate of the trajectory. To determine the possibility of shooting one must compare the height of the ordinate of the range of the crest with the height of this crest above the gun position.

Example. A 76 mm mountain gun is firing long range shell at a range of 5,000 metres. Distance to crest 2,800 metres, height of crest above gun = 280 metres. (fig 43, sketch 1).

Fig 43. Determing the possibility of clearing the crest.
Sketch 1. Target and gun position are on the same level; sketch 2 target and gun position are on different levels.

From the table of ordinates, relating to a range of 5,000 metres (table 34) opposite the distance to the crest of 2,800 metres we find the ordinate 390 metres. This ordinate is greater than the crest, there fore shooting is possible.

When the target and the gun position are on different levels (fig 43, sketch 2) it is necessary to determine beforehand the horizontal range of flight of the shell X for the angle of elevation θ, calculated for shooting at the target, which is made up of the range angle α_0 and the correction for the angle of sight to be found in table 33. This same correction as we illustrated earlier is the sum of the vertical angle ε and the correction for the range angle Δα. Then employing the tables of ordinates from the distance of flight already found and from the distance to the crest, we determine the height of the ordinate and compare it with the height of the crest above the gun position.

Example. A 76 mm mountain gun firing long range shell; height of gun position above sea level, 2,000 metres, height of target 1,400 metres, height of crest 280 metres, horizontal range to target 5,000 metres and to the crest 2,800 metres.

122 In the complete range tables we find the angle of elevation corresponding to a range of 5,000 metres to be 238 divisions, and from the tables analogous to table 33, the correction for angle of sight to be 117 divisions. Consequently the final angle of elevation is 238 - 117 = 121 divisions of the sight.

From the same tables we find that the horizontal range corresponding to this angle of elevation to be 3,000 metres. In this case the range to the crest is 2,800 metres and the ordinate height is 31 metres. As the difference in height of the crest is + 280 metres firing is impossible.

In order to take dispersion (100% zone) into account it is necessary to reduce the ordinate by 4 B_B, corresponding to the range to the crest.

29. Meteorological peculiarities of preparation for firing in mountains.

A characteristic of the meteorological conditions in high mountainous country is the low barometric pressure, due to the low density of the air. As is already known when meteorological conditions differ from the standard conditions to a considerable degree the introduction of corrections becomes unreliable. In addition under conditions of such low air density the general elements of the trajectory are altered.

For this reason at the present time, special mountain range tables for use in high mountainous regions are employed, the normal (table) meteorological conditions used are not those which are used in flat areas.

Mountain range tables are composed for conditions characterized by heights of 1,000, 1,500, 2,000 and 3,000 metres above sea level.

Table conditions for these range tables are as follows (table 35).

Table 35.

Rangetable at heights	1,000	1,500	2,000	3,000
Ground pressure in mm	670	630	590	520
Ground air temperature in °C	+10	+6	+3	-3
Charge temperature in °C.	+10	+6	+3	-3

Regarding table determination of air temperature according to height, this is done in the usual manner: equal decrease of 6·328° for each 1,000 metres of height.

When calculating the meteorological data for the preparation of fire in a high mountainous area, it is necessary to remember that apart from the great difference in height between the troop and the target there wi be a big difference in height between the troop and the meteor telegram. This circumstance calls for special rules for the choice of data from th telegram, but first of all it calls for special rules in the composition of the telegram.

The mountain meteor telegram AMS (AMC), differing from the normal, contains instead of the deviations in temperature and pressure from normal, their actual values. Therefore, the gunner must himself find the differences corresponding to the range tables which he is using. Instead of ballistic differences in temperature, the temperature for each trajectory is given, analogous to the ground temperature. The difference between this temperature and the table one must also be determined by the gunner. We will examine below the method of using this telegram.

Apart from low pressure in mountainous areas, these other peculiaritie in meteorological conditions should be noted:

a) Sharp difference between the ground temperature in the shade and in the sun, the windward and leeward sides of ridges, especially in summer
b) Movement of air (wind) in the lower layers of the atmosphere does not take place horizontally but follows the undulations of the ground
c) In the lower layers of the atmosphere the direction of the wind follows vallies and ravines
d) The speed of wind increases sharply on crests and summits and decreases on the leeward side
e) Development of powerful up-currents over areas strongly heated by the sun
f) Greater and sharper variation in meteorological conditions than on the plains.

The peculiarities indicated all lead to the fact that the meteorological conditions given in the meteor telegram will differ considerably from the conditions prevailing in the area of the gun position and particularly in the target area.

Therefore in mountainous country the AMS must be located at a height corresponding to the mean height of the locations of the batteries, strictly conforming to the rules given in the instructions for the Artillery Meteorological Service. The AMS bulletins must be issued as often as possible.

For the same reasons in mountainous country great variation in meteorological conditions along the path of the flight of shell are observed.

All these peculiarities often lead to the fact that shooting on unobserved targets without ranging (with a full preparation) in mountainous areas turns out to be pointless. (impractibable).

However, because of the difficulties of ranging a full preparation for firing with a thorough consideration of all meteor factors in mountainous has no less importance than in the plain

Under the conditions where the differences in height between the AMS and the battery, and also battery and target it is necessary to make a series of calculations in advance in order to work out the meteor correction:

a) Convert the pressure and temperature given in the AMS telegram according to the height of the battery.
b) Ballistic means are taken from the meteor telegram at the same time taking into account the height of target above the gun position.
c) The height of trajectory for the selection of ballistic means from the meteor telegram must be altered according to the height of the AMS above the gun position.

The measures enumerated will be analysed below.

p.124 30. <u>Utilization of the Mountain Meteor Telegram of the AMS.</u>

As indicated above the mountain range tables are calculated for "normal" conditions. For particular conditions the mountain meteor telegram of the AMS is produced. The utilization of this telegram we will analyze in an example.

Let us assume that fire is conducted with a 76 mm mountain gun firing a long range shell. Height of gun position above sea level - 2,100 m. Map range to the target 7,200 metres. Height of target above sea level 2,390 metres. Directional angle to the target 32-50. The AMS meteor telegram is received in the following form:
Telegram N0.34. Mountain-meteor 250620 -1620 - 51402 - 02 - 003507 - 04 - 513709 - 08 - 523810 - 12 - 523809 - 16 - 513911 - 20 - 534112.

'Converting the pressure to that of the battery position' need only be done when the difference in heights between the battery position and the AMS is more than 30 metres, since within these limits the difference is insignificant. In the case given the difference is much larger (2,100 - 1,620 = 480 metres), and at the same time the battery is higher than the AMS. This means that the pressure at the gun position must be less than at the AMS.

It would appear that one could utilize the factor indicated in Section 28 that is, that for every 10 metres alteration in height the pressure alters by approximately by 1 mm. However, this not sufficiently accurate. This factor may only be utilized when the difference in height between the AMS and the gun position does not exceed 100 metres. One can only obtain accurate results by employing the tables of the barometric ladder. When employing the barometric ladder it is necessary to bear in mind the following rule: the difference in pressure at two differenc points is equal to the difference in height divided by the barometric step; the pressure is greatest at the lowest point.

We obtain the barometric step from the tables. Here we can not make use of the mean pressures and temperatures between the AMS and the gun position as these have been obtained only at the AMS. Therefore we take the step according to the pressure and temperature obtained at the AMS (614 mm + 2°), this equals 13,1 metres.

Having divided the difference in height between gun position and [illegible] (480 metres), by the barometric step we obtain the difference in pressure between these points:

480:13,1 = 37 mm (in round figures).

As the gun position is higher than the AMS the pressure at the [illegible] position must be less by these 37 mm. Consequently the pressure [illegible] gun position is - 614 - 37 = 577 mm.

'Conversion of ground temperature taken at the AMS to that of the height of the gun position' must be carried out only when the difference in height between the AMS and the gun position exceeds 100 metres. [illegible] this end one utilizes the "normal" decrease of temperature of the [illegible] with the increase in height: 0.006328 for 1 metre or approximately 6° for every 1,000 metres.

125. 'The difference of temperature at two points may be taken as being equal to the difference in height multiplied by $\frac{6}{1,000}$ the temperature being highest at the lowest point'. In this instance the ground temperature at the gun position will be less by $480 \cdot \frac{6}{1000}$ = 3° approx. that is it will be - + 2° - 3° = -1°.

It is quite understandable that when a barometer and a thermometer [illegible] available at the gun position there is no need to convert the temperature and pressure taken at the AMS to the height of the gun position as [illegible] can be measured at the gun position. It is only necessary to zero the [illegible] barometer as often as possible (twice a month) with the AMS barometer.

The taking into account of the height of the target above the gun position for the selection of data from the meteor telegram must be mad because the table of height of the trajectory to be found in the range tables on the basis of map range, in the case of the target being considerably higher will not give the true height of the trajectory which will pass through the target (fig 44).

As is known the selection of 'ballistic means' from the meteor telegram depends on the height of the trajectory, this height being calculated as from the horizon point of the trajectory.

From fig 44 it is seen that the table height of trajectory Y corresponding to the map range is considerably less than the true height of trajectory Y', passing through target Ц. If the "ballistic means" had been taken for the first trajectory a considerable error would have crept in.

Fig 44. Determination of the height of the trajectory.
Y = height of trajectory according to map range
Y'= height of trajectory determined by angle of elevation.

Therefore, in such cases 'the height of the trajectory is taken from the range tables not according to range but according to angle of elevation which is made up of the table range angle o corresponding to the map range and the angle of sight to be found in table 33'.

One must only take the height of the trajectory according to the angle of elevation when the correction for angle of sight (angle of the target plus range angle of elevation) is more than 25 divisions of the sight.

126. In this instance the height of the target above the gun position is:
2390 - 2,100 = + 290 metres.

From the tables we find that with this particular difference in height and at a range of 7,200 metres the correction for angle of sight equals + 48 divisions. This means that we must take into account the height of the target above the gun position.

From the mountain range tables for heights above 2,000 metres (as the gun position is at a height of 2,100 metres above sea level), for long range shell we obtain the range angle, corresponding to the range of 7,200 metres, which is equal to 407 divisions of the sight, consequently equals - 407 + 48 = 455 divisions of the sight.

According to this angle of elevation taking it to be the table/range angle for firing we obtain from the tables the height of the trajectory. This is 1,157 metres. If one takes the height of trajectory for a range of 7,200 metres it will be equal to 957 metres, that is 200 metres less.

The taking into account of the height of the AMS above the gun position when selecting the "ballistic means" from the meteor telegram is based on the following considerations.

The heights of trajectories for the working out of the ballistic wind is done by the AMS at the highest point of their own position. In other words it is assumed that the gun position is at the same height as the AMS.

In the event of the gun position and the AMS differing in height to a considerable degree this assumption will lead to considerable errors as two identical trajectories whose heights have been calculated on different levels will obviously find themselves under different meteor conditions as may be seen from fig 45.

Fig 45. Influence of meteorological conditions on two identical trajectories at different heights.

In order to avoid these errors one must take the values of the wind from the meteor telegram, not for the actual trajectory (whose height has been calculated from the highest point of the troop) but for a theoretical trajectory, with the proviso that the ballistic be the same as for the actual trajectory. The height of such a theoretical trajectory is obtained on the basis of the following considerations.

127. If we allow that the actual wind alters according to the height in a regular manner it is found that the ballistic wind will correspond to the actual one on the mean height of the position of the shell along the trajectory. As proven by external ballistics this mean height (the height of the "mean ordinate" of the trajectory) is equal to two thirds of the height of the highest point of the trajectory. These positions are clearly shown in fig 46. In fig 46 diagram 1 several ordinates are shown (y', y2, y3 and so on) and the greatest ordinate, that is the

height of trajectory (Y). The arithmetical mean of all the ordinates will give the height of the mean ordinate y_{cp}. As already stated it is

$$y_{cp} = \frac{2}{3} Y.$$

Fig 46 diagram 2 illustrates a wind changing evenly with the altitud The value of the actual wind W at the height of the ordinate (2/3Y) is in this instance equal to the ballistic wind for the whole trajectory.

Fig 46. Height of the mean ordinate y_{cp} of the trajectory and wind W at this height.

Although this relationship of the wind only applies in the case of a constant alteration of the meteorological conditions according to altitude, which in actual fact does not happen, we can nevertheless, make use of it to a sufficient degree of accuracy.

If we take two trajectories differing in height then on the basis of what has been stated above, we may take it that the ballistic wind for these two trajectories will be the same if the values of the actual wind are the same at heights equivalent to 2/3 of one trajectory and at the same time 2/3 of the height of the other. It is evident that this situation is only possible when the two points corresponding to these heights lie along along the same horizontal level MN (fig 47).

128. Fig 47. Determination of the height of the trajectory in the event of the troop and the AMS being at different heights.

From the figure it is evident that $\frac{2}{3} Y_a + H = \frac{2}{3} Y_b$,

where H is the increase in height of the AMS above the troop. From this formula we obtain: $\frac{2}{3} Y_a = \frac{2}{3} Y_b - H$.

Multiplying both sides of the equation by 2/3 we obtain:

$$Y_a = Y_b - \frac{3}{2} H = Y_b - 1,5 H.$$

When the AMS is situated lower than the troop, the formula will be reversed, and we then obtain: $Y_a = Y_b + 1,5H$.

The following rule issues from these formulae: 'If the AMS is above the gun position, then to select the ballistic wind from the meteor telegram a trajectory is taken whose height is one and a half times the difference in height between the AMS and the gun position, lower than the true trajectoty and if the AMS is below the gun position antrajector is selected which is above the true trajectory by one and a half times the difference between the AMS and the gun position.'

It is quite evident that the height of the true trajectory is obtaine by the angle of elevation as already stated.

Such a re-calculation of the heigh of the trajectory is carried out only in cases where the difference in height between the AMS and the gun position exceeds 100 metres as only in such a case will the difference in the ballistic wind be noticeable.

All that has been said above regarding the working out of the height of the trajectory to find the ballistic wind is fully relevant to the selection of data on temperature, given in the meteor telegram for each trajectory.

According to our example we have:

- height of trajectory by the angle of elevation 1,157 metres;
- AMS is 480 metres above the gun position;
- one and half ti es the difference in height = 480 x 1,5 = 720 metres.

In view of the fact that the AMS is belos the gun position, the "ballistic means" must be taken from the meteor telegram on a trajectory whose height is - 1,157 + 720 = 1,877 metres.

129 This will be: temperature -2°, direction of wind 40-50 and its speed 12 metres per second (we find by interpolation between heights 1600 and 2,000 metres).

The temperature corresponding to a trajectory of 1,877 metres is likewise converted to the height of the battery employing the same ratio 6° to every 1,000 metres.

In our example this will be: $480 \frac{6}{1,000} = 3°$ approximately

And finally, the temperature for trajectory of 1,877 metres at the troop will be -2° - 3° = -5°.

31. Calculation of corrections when shooting in the mountains.

When preparing for firing in the mountains, it is necessary first of all, to choose the mountains range tables corresponding to the height of the troop above sea level. The range tables may be chosen according to the following table.

Height of troop above sea level.	Height for which range tables are compiled.
From 0 to 500 metres	0 metres.
" 500 " 1,250 "	1,000 "
" 1,250 " 1,750 "	1,500 "
" 1,750 " 2,500 "	2,000 "
Higher than 2,500 "	3,000 "

In our example the height of the troop above sea level equals 2,100 m Consequently, it is necessary to take the range tables for a height of 2,000 metres. These tables are compiled for the following normal conditions: pressure 590 mm, ground temperature of the air and charge temperature +3°. Since after conversion to battery height we obtained: pressure 577 mm and temperature for the trajectory at 1,877 m = -5°, then the deviation of these elements from the table values is;

- deviation of pressure 577 - 590 = -13 mm;
- deviation of temperature -5 - (+3) = -8°.

To these deviations we will introduce corrections according to the range tables. When doing this it is necessary to bear the following in mind.

The correction data on the meteorological and ballistic factors, given in the range tables are calculated on the basis that the influence of the appropriate factor is spread over the whole trajectory up to its end. In addition from fig 44 it is seen that if the target is situated considerably higher than the gun position then the actual trajectory relevant to the angle of elevation G ends at the point of the target and consequently the influence of these factors is brought to bear only up to the
130 point I. Inversely if the target is below the gun position (Fig 48) then the influence of these factors reaches beyond the table point of impact C, located on the guns' horizon. The influence of factors altering the range and direction of flight of the shell may be taken as being proportional to the time of flight of the shell. As may be easily seen in figures 44 and 48, if we take corrections for the table trajectory corresponding to the angles of elevation we may obtain considerable errors, as the time of flight of the shell to the target will not be equal to the time of flight along such a trajectory.

Fig 48. Influence of meteor factors in the case of a target being located considerably lower than the gun position.

In accordance with "the beginning of the rigidity of the trajectory" with the concomitant allowance for the equality of slant and horizontal ranges, we may take it that that actual trajectory OS_1, is equal to the table trajectory OS_1P, corresponding to the map range to the target and consequently the time of flight of shell along these two trajectories is equal.

In that case "the beginning of rigidity" is applicable to a far greater extent than in the matter of the influence of the angle of sight on the angle of elevation.

On the basis of what has been said above in the course of preparation for firing in mountains 'Corrections are taken from the range tables in according with the map range to the target' but never by the final angle of elevation as it was done in determingin the height of the trajectory (Sec 29)

Following our example we find the table corrections in the range table for heights of 2,000 m, according to map range of 7,200 m. This will be:

on W_x ..... $+\frac{214}{10}\,8{,}0 = +171$ m. (obtained after breaking down the wind on components in normal manner)

on Δh $-\frac{26}{10}13 = -34$ m. on ΔT $+\frac{127}{10}8 = +102$ m.

131 If in addition to this we have : fall of initial speed (velocity) of pivot gun $\Delta v_9 = 1{,}5\%$ and charge temperature $t^o_{3HD} = +5^o$, then we add the corrections on Δv_o and on $\Delta t_{ch} = +5^o - (+3^o) = +2^o$: on $\Delta v_o = +72 \cdot 1{,}5 = 108$m. On $\Delta t^o_{ch} = 72/10 \times 2 = 14$ m. Sum of corrections equals + 333 metres. Corrected (calculated) range equals 7,200 + 333 = 7,533 metres.

The corrections for flank wind and derivation and final corrections for angle of sight are taken on calculated range.

32. Firing in mountains at targets located on a horizontal plateau.

In the case of targets situated on a level plateau and where the obxervation post is approximately on the same level as the target, ranging and fire for effect are conducted according to normal rules as for firing on level ground.

Should the area of the plateau be small and should there be a danger of ranging rounds falling outside the limits of the plateau and be unobserved, ranging is commenced with single rounds with fragmentation shell with the angle of sight increased by from fifteen to twenty divisions over and above the calculated setting. Having obtained airbursts over the area of the plateau, the bursts are then lowered to the horizon of the target and one goes over to firing with HE shell.

In the event of the target being on a level ppateau and the OP being above the target to an appréciable degree, ranging may be conducted either by observation of bursts according to the table with 'one-sided' ranging.

'Ranging by observation of bursts'. If the displacement of the gun position in relation to the line of observation is inconsiderable (correction for displacement not more than 2-00), then due to the fact that the OP is above the target, observation for range is obtained from bursts falling not only on the line of observation but also to one side of it. Therefore it is not necessary to introduce corrections to bring the bursts on to the line of observation. It is more profitable to hold the bursts on the line target, that is the line gun-target. In this instance bursts obtained below the target horizon will be minusses and above - plusses.

'Ranging from the tables with 'one-sided' observation! To construct a table or graph, millimetre or squared paper is used, on which two lines perpendicular to each other are drawn. The point of intersection of these lines is taken to be the point of the target, the horizontal line is used to plot the lateral displacement of bursts from the target [illegible] vertical one for displacement for height. When plotting the bursts [illegible] the graph, the scales for the vertical and horizontal lines are not the same: the scale for the vertical line is ten times greater than [illegible] for the horizontal line.

132. In carrying out ranging the extent of the corrections [illegible] for line and range must be correlated with the size of [illegible] the case of the plateau being small the dial sight is [illegible] to twenty divisions and the range sight by four divisions.

The order for ranging will be given as an example. [illegible] following scale for pplotting bursts on the graph: five divisions [illegible] dial sight in one square - along the horizontal line, and one [illegible] the dial sight in two squares along the vertical line.

Let us assume that after the first round on range setting [illegible] following observations are obtained (in divisions of the dial [illegible] lateral observation - left 10 and for range (for height) - plus 4 [illegible]

Let us plot this point on the graph (fig 49 - point P1).

Fig 49. Shooting by graph in the mountains.

The second round is given on range setting 66. Observations [illegible] left - 25, for range (for height) - 0. We plot the second burst on the graph - point P2.

We connect P1 and P2 by means of a straight line.

It is evident that the line of fire is passing to the left of the target. The setting of the dial sight for the third round is [illegible] in such a way as to bring the line of fire to the other side of [illegible] Taking into account the location of the OP and the displacement of [illegible] second round from the target, we increase the dial sight setting by [illegible] divisions, leaving unaltered the setting of the range sight.

Observation of the third round: Right 8, for range (for height) minus 2. We plot the third burst on the graph - P3. We connect [illegible] [illegible] and draw a straight line through the point of the target parallel [illegible] the line P1 - P2.

The distance P2 - P3 corresponds to twenty divisions of the dial sight [illegible] P1 - P2 to four divisions of the range sight. Consequently in order [illegible] go over to fire for effect it is necessary to switch to the left [illegible] [illegible] eight divisions of the dial sight (as P3A = 2/5 P3P2 = 2/5 20 = [illegible] [illegible] the range sight by one division (as AII = 1/4 P1P2 = 1 [illegible])

[illegible] event of the displacement being inconsiderable, two rounds [illegible] [illegible] fired [illegible] one setting of the dial sight and on two different [illegible] of the range sight. In order to determine the correction for the dial sight [illegible] to count the number of squares from the point of the

133 target to the line P1P2 along the horizontal line and this figure is multiplied by the co-efficient of range and by the scale adopted (by the number of the divisions of the dial sight to each square). To obtain th correction for the range sight, the number of squares from point P2 to t horizontal line are taken and this figure is multiplied by the scale ado ted (by the number of divisions of the range sight to each square).

33. Shooting in the mountains at targets situated on slopes.

When the target is situated on a slope facing the OP, plusses will b observed above the target and minusses below it (fig 50).

Fig 50. Observation of bursts in the case of a target situated on a sl facing the OP.

Consequently in this case it is possible to assess the range without bring the bursts on to the line of observation and ranging is conducted according to the same rules as for a target situated on a level plateau, but with the OP being at an elevation considerable higher than the targe (Section 32).

Ranging on targets located on extremely steep slopes is carried out i the following manner.

Having obtained the first burst to one side of the target a correctic for line is introdueed in the usual manner and the second round is fired. If the lateral displacement of the second round is small (not more than 0-10) then the height of the round above the target is measured in terms of divisions of the sight and the correction for elevation is calculated. The correction for elevation is equal to the height of the burst above the target in terms of divisions of the sight multiplied by the co-efficient of the range factor. If the burst is above the target the correcti for elevation is minus, and if below - plus.

Having introduced the correction for elevation and if necessary for line, four rounds gunfire is ordered. Having determined the mean excess of height in terms of angles a new correction for elevation is introduced and fire for effect is carried out.

The method given for calculating corrections gives satisfactory accuracy for flat trajectory fire. In the case of high trajectory fire the correction errors may be considerable particularly in the event of the bursts being above the target to a considerable degree.

134 In the case of targets lying on slopes, ranging on measured deflection has its own peculiarities, arising out of the fact that correction for range under these conditions is not mathematically equal to the measured displacement.

Let us assume that the slope faces the gun position and forms angle α with the horizon (fig 51).

Let us also assume that the burst took place at point P.

As a result of observing the burst from two directions, its displacement from the target will be determined, equal to PA (projection PI to the horizon). If after this a correction for the range sight is introduced corresponding to the displacement PA, then as may be seen from fig 51 the burst will occur not at point I, but at point B (fig 51)

Fig 51. Determination of the size of displacement of bursts from the target, when situated on a slope.
α = slope of ground; θ_c = angle of descent; a = measured displacement of burst from target; PI_1= actual size of the correction.

Consequently, in order to direct the trajectory at the target it is necessary to alter the range not by the size of the measured deflection, but by value of PI_1.

The relationship between the size of the correction for range and the measured deflection of the burst from the target may be arrived at by the following method.

From fig 51 it is seen that - $PI_1 = PA + AI_1$.

From triangle PIA we get: $AI = PA \tan\alpha$

From traingle IAI_1 " " : $AI = AI_1 \tan \theta_c$

Since the left parts of the last two equations are equal, the right hand halves are likewise equal, i.e.

$$PA \tan\alpha = AI_1 \tan \theta_c.$$

Therefore - $$AI_1 = PA \frac{\tan}{\tan \theta_c}$$

Consequently, $$PI_1 = PA + AI_1 = PA + PA\frac{\tan\alpha}{\tan \theta_c} = PA\left(1 + \frac{\tan\alpha}{\tan \theta_c}\right).$$

135 Writing down the value of deflection PA through d and the value of the correction for range PI_1 through d, and bearing in mind that the correction carries the sign opposite to the sign of deflection , we have:

$$d = -a\left(1 + \frac{\tan\alpha}{\tan\theta_c}\right).$$

From the above formula it follows that the correction for range is numerically greater than the value of the measured deflection and depends on the angle of slope of the ground α , and on the angle of descent θ_c.

Example. Firing is conducted from a 152 mm gun/how M 1937. Charge 8. Range 4,000 metres; target situated ona slope facing gun position; angle of slope of ground $\alpha = 20°$. As a result of taking a resection from two points the deflection of the burst was determined as being a = - 100 metres. Determine the correction.

Solution. From the range tables for charge 8 at 4,000 metres we have c = 11° 55'. Correction for range:

$$d = -a\left(1 + \frac{\tan 20°}{\tan 11°55'}\right) = (-100)\left(1 + \frac{\tan 20°}{\tan 11°55'}\right) = + 272 \text{ metres.}$$

If the slope faces one of the flanks, then when altering the setting of the dial sight, the range of the shells will alter when firing one and the same angle of elevation. The range will increase when turning the dial sight in the direction of the lowest point of the ground and decrease when turning in the direction of the highest point of the ground.

The extent of the alteration is dependent on the angle of slope of the ground and on the angle of descent. The greater the angle of slope of the ground, the greater the alteration in range. The greater the angle of descent, the less the alteration in range, when the angle of slope of the ground is the same.

This characteristic of firing in mountainous areas [illegible] account in ranging by observation of bursts as well as [illegible] measured deflections.

When ranging by observation of bursts with a target [illegible] slope facing one of the flanks, a correct estimation [illegible] be made if the bursts fall on the line gun target. [illegible] the event of displacement, the bursts must not be [illegible] line of observation but must be kept on the line gun-target [illegible] bracket must be obtained on the same setting of the dial sight [illegible] ranging on measured deflections, the correction after the [illegible] observed must be made only on the dial sight. After a [illegible] gun target is obtained one can introduce a correction for [illegible]

34. <u>Firing at targets situated in very broken country.</u>

When firing HE shell in very broken country, observation of [illegible] becomes very difficult as a considerable proportion of rounds [illegible] lost in the folds of the ground and will not be visible [illegible]

136 Therefore, ranging under such conditions is carried out [illegible] ~~tion~~ shell until an eight of a four division bracket is [illegible] Changing over to firing HE fragmentation shell, the mean [illegible] above the target must be multiplied by the range factor [illegible] is decreased by the figure obtained, thus bringing the [illegible] target horizon. Subsequent ranging is carried out by [illegible] mentation shell according to the rules set out above (Section [illegible]

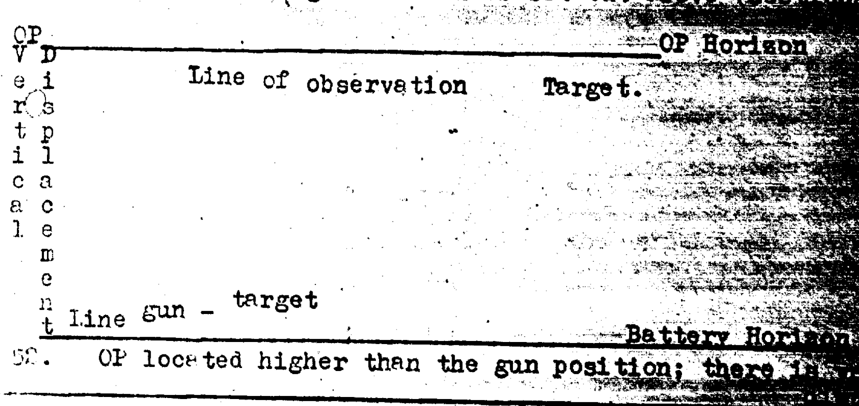

Fig. 52. OP located higher than the gun position; there [illegible]

When commencing ranging by means of air bursts it is necessary [illegible] into account the peculiarities of bringing air bursts on to the [illegible] observation.

The characteristics of ranging under these conditions are governed by the existence of vertical displacement of the OP in relation to the gun position.

OP Horizon.

Battery horizon.

Fig 53. Op is above the battery; there is no vertical displacement.

Vertical displacement should not be confused with the height of the OP above the gun position.

Vertical displacement is the perpendicular dropped from the point of location of the gun position to the line of observation (fig 52).

The OP may be above the gun position while at the same time vertical displacement will be absent. (fig 53).

Finally, the OP and the gun position may be on the same level while at the same time vertical displacement will exist (fig 54).

137. As may be seen from the diagrams vertical displacement exists in a case where the projection of the line gun-target and the line of observation in the vertical plane do not coincide. From the same diagrams it is evident that a comparison may be easily made between the vertical and horizontal displacements.

gun target.
Line observation
of
Line
Horizon of OP and battery.
Vertical Displacement.

Fig 54. Op and gun position located at the same level; vertical displacement exists.

But if the correction for lateral displacement is calculated according to the formula $ПС = \frac{Б \sin \alpha}{0{,}001\, Д_б}$,

it is evident that the correction for vertical displacement may not be obtained by means of the same formula. In practice it is extremely difficult to determine the vertical base, (the distance of the OP from the gun position in the vertical plane) and also the angle within the same vertical plane.

The correction for vertical displacement ($ПС_B$) is equal to the angle АПБ (fig 52).

From triangle АБП we have: $Мк + Мб = \angle АПБ$, or $Мб - (-Мк) = \angle АПБ$, where the angle Мк is taken with its own sign.

This formula is correct for all interrelationships between gun position, OP and target, that is the correction for the vertical displacement equals the algebraic difference between the angle of sight to the target from the gun position (Мб) and the angle of sight to the target from the OP (Мк); the angles Мк and Мб are taken with their own signs.

Example. Мк = +0-30; Мб = +0-55.

Correction for vertical displacement will be equal to

$ПС_B$ = 0-55 - 0-30 = 0-25.

138. When shooting by observing bursts, observation for range can only be obtained from air bursts, which are along the line of observation.

The burst P_1 (fig 55) brought on to the line of observation in the vertical plane, at the commencement of ranging, with the alteration of the sight will move to point P_2, that is will move from the line of observation and will not give an observation for range.

To obtain an observation for range one must once again bring the burst on to the line of observation, that is move it to point P_3, which may be achieved by an appropriate alteration (decrease) in the setting of the elevation.

Evidently in decreasing the setting of the sights the burst will likewise be moved from the line of observation and in this instance in order to maintain it on the line of observation, one must increase the elevation setting.

Thus when firing in mountainous country if considerable vertical displacement is present, it is necessary to bring the bursts on to the line of observation, not only within the horizontal plane (dial sight switch), but also in the vertical, which is achieved by a correction for elevation.

Line of observation.

Range correction (elevation)

Fig 55. Getting the bursts on to the line of observation when vertical displacement exists.

The formula for determining the elevation correction may be arrived at in the following manner.
From fig 56 we have; Elevation correction = $\alpha - \beta$.

OP horizon

Battery horizon.

Fig 56. Determination of elevation correction Шур (Shur).

But $\alpha = \dfrac{B}{0{,}001\,Д_1}$ and $\beta = \dfrac{B}{0{,}001\,Д_2}$

where – B is the vertical disppacement;
$Д_1$ the range to the first burst;
$Д_2$ the range to the second burst.

From which we get: $Шур = \dfrac{B}{0{,}001\,Д_1} - \dfrac{B}{0{,}001\,Д_2} = \dfrac{1000\,B\,(Д_2 - Д_1)}{Д_1\,Д_2}$

From triangle АБП we obtain: $B = БП \sin\angle АПБ = \ \sin(M6 - Mk)$,
where $Д$ is the range to the target.
Inserting the value of B in to the formula for elevation correction (Шур)

we obtain $Шур = \dfrac{Д \cdot 1000 \sin(M6 - Mk)(Д_2 - Д_1)}{Д_1\,Д_2}$

without great error we may take it that $1000 \sin(M6 - Mk) = M6 - Mk$
$Д_1 Д_2 = Д^2$

Then $Шур = \dfrac{(M6 - Mk)(\ \ 2 - \ \ 1)}{Д}$

If we take the difference in ranges $(Д_2 - Д_1)$ as being equal to 100 metres, then we get the elevation corr[illegible] calculated for alterations of range of 100 metres:

$$Шур = \frac{(M6 - Mk)100}{Д} = \frac{M6 - Mk}{0{,}01\,Д6}.$$

Example. Angle of sight to the target from the battery M6 [illegible]. Angle of sight from the OP to the target Mk = –0–50 (OP higher than [illegible]. Range 5,000 metres. For a 100 metre bracket the elevation correction will equal

$$Шур = \frac{M6 - Mk}{0{,}01\,Д6} = \frac{180 - (-30)}{50} = \frac{210}{50} = 0\text{–}04.$$

In practice, however, it is not always possible to calculate the elevation correction employing the formula. In this case the elevation correction is determined by means of ranging, for which purpose after the initial group of rounds, fired as air bursts, which have given observation for range, a second group is fired, after having altered the setting of the sight and the fuze, by the required number of [illegible], but maintaining the same elevation.

Having multiplied the difference between the meanheights of bursts of the two groups by the range factor, we will obtain the correction [illegible] elevation corresponding to the already made alteration on the [illegible].

By studying figs 55 and 57 the following rules for the [illegible] the alteration to elevation Шур, (elevation correction) are [illegible]
'If the OP is situated above the line gun – target then in [illegible] the range sight setting, the elevation setting decreases, and in [illegible]ing the range setting, it increases by the value of the elevation correction. (Inverse to the alteration to the range sight)'

Fig 57. Employment of the correction for elevation.

'If the OP is situated below the target, then in altering (increasing) the range sight setting, the elevation setting increases by the value of the correction for elevation and in decreasing the range sight setting it [illegible] (In the direction of the correction to the range sight setting.)

35. Night Firing.

Night firing may be conducted: a) against targets illuminated by searchlight; b) against targets illuminated by illuminating shell or flares; c) against unilluminated targets.

The latter may be either completely unobserved during the hours of darkness or observed for very brief periods (gun flashes), or observed over comparatively long periods of time (burning villages, camp fires, car headlights etc).

Preparation for night firing is normally carried out in the hours of daylight. For night firing, night aiming marks are selected at the gun position: one basic and one in reserve, one as far away from the other as possible (the angle to them from the pivot gun must be not less than 10-00). The distance from the guns to the aiming marks must be not less than 200 metres.

On the selected aiming marks, lanterns are placed in such a manner as to be screened from ground and air observation. The sight settings of all the guns on both the night aiming marks are recorded and also the difference in the settings of the dial sight for day and night aiming marks. To prepare the OP for night firing two lanterns are placed in front of it (basic and reserve) the lights in the interest of camouflage being directed towards the OP. These lanterns serve as reference points
141. for night firing. They must be placed at a distance of from two to five hundred metres from the OP on lines forming angles of from 5-00 to 10-00 with the zero line.

With the aid of the steroscopic telescope placed along the zero line basic calculations are made on the lights and these are recorded.

Ranging and firing for effect against targets illuminated by searchlights, star shell or rockets (flares) is conducted in accordance with the normal procedure for firing in daylight,

It is desirable that the illumination of the target should be continuous throughout the period of the whole shoot. If continuous illumination of the target is impossible then complete coordination of the work of the guns firing the illuminating shell and the guns performing the fire task is essential. The order "Fire" for both groups of guns must be given by the commander of the battery firing for effect with the objec of ensuring that the guns firing the illuminating shell should fire from fifteen to twenty seconds before the guns firing for effect.

Ranging on non-illuminated targets which, however, disclose themselves through gun flashes or fires is conducted on measured switches cross references on the bursts being taken from the points of observation.

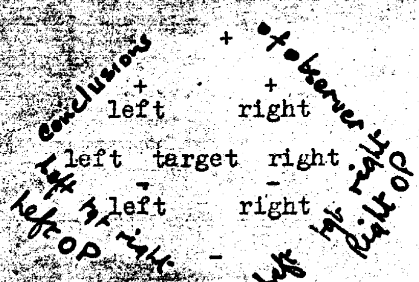

Fig 58. Conclusions of the observer on the signs of bursts on the basis of coordinated indications of observations.

Fig 59. Plan of night firing (to table 36).

If for some reason it is not possible to illuminate the graticule of the optical instrument and consequently it is impossible to determine the angle of deflection of bursts from the target ranging is conducted on the basis of comparing information obtained from the points of coordinated observation. In this case each point signals only the sign of lateral displacement, without indicating its extent whether it is to the right, left or correct. With this method of ranging, the line gun target must pass between the points of observation. Comparing the information obtained from the OP's, referring to the same burst it is poss-
142 ible to work out its position in relation to the target. Thus for example, if the right hand OP signals right and the left one left it is evident that the burst is a plus, if the right hand OP signals right and the left hand also right, the burst has a deflection to the right etc.

In order to avoid delay and possible errors in determing the displacement of the burst one should make use in the course of ranging of a previously prepared table shown in fig 58.

Ranging is conducted with one gun.

Corrections to the dial sight during the initial rounds should be of from twenty to forty divisions and corrections for range of from four t eight 4 X, depending on the method and accuracy of preparation. For all subsequent rounds the size of corrections is halved.

Corrections for line and for range may be given simulteneously or on after the other.

An example of ranging is given in table 36, below and is diagrammati ally illustrated in fig 59.

Table 36.

No of rounds.	Dial Sight.	Range.	Observation of left OP	Obsvn Rt OP	Conclusions of observer and basis for orders.
1	57-20	94	Left	Left	Burst left.
2	+0-40	94	Left	Right	Plus. Try for 8 div bracke
3	-	86	Right	Left	Minus. Halve range bracket.
4	-	90	Right	Right	Right. Halve line bracket.
5	-0-20	90	On tgt	Left	Left/minus Halve line and range brackets.
6-7	+0-10	92	Left Left	Right Right	Plusses. Confirm near end of bracket.
8-9	-	90	Right Right	Tgt. Left	Right and minus. Halve bracket for line and range and go to fire for effect.
10-13	-0-05	91	Left Tgt Left Right	Right Right Tgt Left	Covering group; Continue firing on these settings.

At night fir for effect may be conducted either after previously carried out night ranging, according to the rules given above, or withou ranging. Neutralization of targets not illuminated and which do not disclose themselves through gun flashes or fires is possible to achieve
143 without ranging only in the case where the coordinates of the targets are known. The initial settings may be determined by the following methods:

a) on the basis of full preperation;
b) by calculating the switch from a reference point ranged on in dayli in this case the differences in corrections brought about by the meteor and ballistic conditions varying at the time of ranging on th reference point as compared with the time of firing for effect must be taken into account;
c) calculating the switch from a fictitious reference point(on the ground or in the air) created at night, immediately prior to firing for effect;
d) on the basis of data supplied by the renging gun.

Targets which disclose themselves through gun flashes or fires may be cross referenced from points of coordinated observation and consequently the coordinates of such targets will be known.

The preparation of the initial settings for firing for effect may be carried out by one of the methods indicated above.

CHAPTER IV

SHOOTING WITH SHELL OF SPECIAL FUNCTION.

36. Types of shell with a special function.

The basic artillery shell is the HE shell.

Thanks to the existence of percussion fuzes of various types and the possibility of setting these fuzes for different actions, the HE shell is employed in solving the greater part of the fire tasks given to the artillery. The HE shell achieves the neutralization and destruction of personnel, the destruction of various types of defensive works and artif-icial obstacles, the destruction of tanks and other armoured vehicles and so on. However, present day battle conditions present artillery with problems which it is either impossible to solve by means of an HE shell with a percussion fuze or require for their solution a very great expend-iture of ammunition. Thus, for example, if the target is situated on a reverse slope, the angle of the slope of the ground being greater than the angle of descent, then when firing an HE shell with a percussion fuze neutralization of such a target is not possible.

Likewise the destruction of an aerostat (captive balloon) ~~equipped~~ cannot be achieved with the aid of an HE shell equipped with a percussion fuze.

In battle, artillery is often given the task of masking either isolated targets or a whole area with smoke. The carrying out of such a task employing the normal HE shell is of course possible, but would mean an excessive expenditure of ammunition.

In order to fulfil such tasks artillery possesses special shell.

Amongst these are;

1) shell for air burst: HE fragmentation (shrapnel). This type of shell can be exploded at any point along its trajectory, that is, at any distance from the gun. From this fact comes the term 'distance shooting!

The shell is exploded by means of a fuze ('pipe') set on a specific setting with the object of obtaining a burst at a specific distance.

The basic task of such shells is the neutralization of captive balloons (aerostats) and the creation of air bursts.

Under certain conditions given below these shells may be used for neutralizing personnel.

2) Smoke shell, intended for the masking of isolated targets with smoke and the laying down of smoke screens.

3) Illuminating shell, used for illuminating ground in the enemy's positions.

4) Incendiary shell, used for starting fires within the enemy's position.

37. The action of the HE fragmentation (shrapnel) shell.

This "brisant" shell is an HE fragmentation shell fitted with a time fuze.

Through the action of the fuze the shell may be exploded at any point along its trajectory depending on the setting of the fuze. At the present time our artillery is equipped with "brisant" shell of 122 and 152 mm calibre with a time fuze D-1 (Д-1). The fuze has 125 divisions. Each division is for 80 - 100 metres depending on the type of gun and its initial velocity and consequently also depending on the charge.

The fuze settings indicated in the range tables for the various distances are calculated on the basis of obtaining a mean height of burst on the gun horizon. In the event of the shell not bursting in the air, the fuze will actuate the shell on impact with an obstacle.

On bursting the shell produces a large number of fragments of varying size and shape. By experiment it has been established that the total number of fragments varies in number between 500 and 3,000 depending on the calibre of the shell, the quality of the metal of the shell casing the type and quantity of the exploding charge.

The distribution of fragments by weight at the time of burst of a steel "brisant" shell is given below in table 37.

Table 37.

Weight of fragments in grams.	Up to 5	6-10	11-20	21-50	more than 50.
No of fragments in %	44	23	27	4	2

Because of the irregular shape of the fragments, they quickly lose their speed of flight because of the resistance of the air.

Therefore the extent of the lethal interval for HE shell (that is, the interval over which fifty per cent of the fragments retain their lethality) is comparatively small and may be taken as being thirty metres for a 122 mm shell and forty metres for 152 mm shell.

Individual large fragments may be lethal over much greater distances.

When a shell bursts, the main mass of fragments flies off from the side walls of the shell and spreads out evenly in all directions in the form of a continuous belt. However, it is quite evident that not all of
146 the fragments, even the large ones will be lethal. Fragments which fly upwards owing to air resistance quickly lose their velocity and donot cause any damage. For the same reason a shell bursting high above the target (over 40 to 50 metres) causes hardly any damage as the fragments flying down and laterally lose their speed, and consequently their lethal power.

From this it follows that when firing HE shell good fragmentation action is only obtained when the interval and the height of burst above the target are correctly chosen. It has been established by trial that the most advantageous height of burst from an HE shell is 12 metres for a 122 mm shell and 15 metres for a 152 mm shell.

Fig 60. Speed of fragment at moment of burst of HE shell. v = speed at moment of burst; v_c consequent speed; v_p speed from burst shell.

Fig 61. Scatter of fragments on bursting of HE shell.

At the moment of burst one must add to the speed of the fragments resultant upon the force of the exploding charge v_p, directed mainly against the walls of the shell, the speed of flight v_c and spin speed v_{bp} which the shell possessed at the moment of bursting. In view of the fact that speed v_{bp} is small relative to speeds v_p and v_c, it may be disregarded, and one may take it that the speed of the fragments at the moment of burst v, will be the sum of speeds v_c and v_p.

~~one[illegible] fragments~~ In respect of fragments originating from the side walls of the shell, one can take it that the directions v_c and v_p will be prependicular to each other (fig 60) and the value v will be obtained from the formula

$$v = \sqrt{v_c^2 + v_p^2},$$

and the angle β formed by the direction of speed v_c, normally towards the side walls of the shell may be determined from the formula tan β [illegible]

147. Thus, the direction of flight of the main mass of fragments will be deflected from the normal direction towards the side walls of the shell by the amount of angle in the direction of flight of the shell. The general character of the spread of fragments is diagrammatically shown in fig 61.

Taking into account the angle of fall of the shell in the vertical plane, it may be taken that the direction of flight of the main mass of lethal fragments will be close to the vertical.

This factor is extremely important as it allows fire to be brought down against personnel not only in the open but also in trenches and sheltering behind vertical barriers.

This indicates also that the most adventageous interval of burst must be close to zero, that is, shells must burst above the target. Falling to the ground fragments are lethal against targets contained within an area of 5 to 7 metres in depth and 40 to 50 metres in length.

38. <u>Dispersion of bursts on air burst shooting.</u>

Having ~~made~~ fired a large number of rounds with HE shell the settings of the dial sight, range sight and fuze remaining unaltered, it is evident that the bursts will not occur on the same point. The phenomenon of the spread of bursts when firing on the same settings is called dispersion. In the case of low air burst firing the dispersion is first of all the result of the dispersion of trajectories along which the bursts occur. In addition we have another cause creating dispersion of bursts [illegible] in the burning rate of the delayed action explosive in the fuze.

Consequently, the position in space of the point of burst depends on the following: a) the trajectory being followed by the shell; b) the time taken for the delayed action explosive within the fuze to burn.

The variation in the time taken for the delayed action explosive in the fuzes to burn is brought about by the following causes: a) [illegible] mechanism of the fuze as well as a variation in the chemical [illegible] and temperature of the delaying element; b) variation in the [illegible] velocities; c) variation in the meteor conditions under which the burning of the delaying element takes place.

Theoritical research as well as firing trials show that dispersion in the case of air bursts follows the law of Gauss.

The area within which all bursts occur is an ellipsoid. The centre of the ellipse is called the mean point of impact.

The projection of this ellipsoid on to the line of fire becomes an ellipse, given in figs 62 and 63. In both figures the point Cд – the
148 mean point of impact, the straight line MN – the mean trajectory, the straight lines AA_1 and BB_1 – extreme trajectories, 4BB away from the mean trajectory.

In fig 62 we will construct over the obtained ellipse 8 equal vertical strips. The width of one strip constitutes the mean deflection of burst for range and is expressed as Bpд. The probability of bursts within each of the strips is determined by means of the law of Gauss and is given in the figure.

Fig 62. The projection of the ellipsoid on to the line of fire. Dispersion for range; interrelationship of Bpд) and Bд.

Fig 63. The projection of the ellipsoid of dispersion on the line of fire. Dispersion for height; interrelationship between Bp_B and B_B.

149 In fig 63 we will construct over the obtained ellipse 8 equal ~~vertical~~ horizontal strips. The width of one strip constitutes the mean deflection of burst for height and is expressed as Bpд) The dispersion of bursts within the strips in terms of percentages, following the law of Gauss, is illustrated in the figure.

As may be seen from the figures, the value Bpд does not equal the value Bд and the value Bp_B does not equal B_B. This is explained by the fact that in the case of air bursts, dispersion is brought about not only by the dispersion of the trajectories themselves but also by variation in the action of the fuzes. As to lateral displacement, Bp6 = B6, as in this instance, the variation in fuze action does not effect lateral dispersion of bursts, the latter being only determined by the dispersion of trajectories.

In order that one may know the extent of the meandeviations in the cas of air bursts, the theoritical values of Bд, Bpд, B_B and Bp_B for a 152 mm howitzer firing HE shell on charge one are given below (table 38).

Table 38.

Range in metres. etc.

From table 38 it is apparent that on short ranges, the values Bpд and Bp_B ARE SEVERAL times greater according to the values Bд and B_B. With an increase in range this difference decreases.

39. Employment of air burst shell.

In section 36 it has already been indicated that the basic employment of an air burst shell is for use against static balloons (aerostats) and for establishing air burst reference points, that is performing tasks which cannot be performed by a shell with a percussion fuze. But does not exhaust the sphere of employment of an air burst shell. Breaking down the data given above we can indicate the following basic characteristics which determine the type of fire task fulfilled by the air burst shell:

150 1. An air burst shell possesses fragmentation action and in addition the nature of the spread of fragments permits its use against personnel not only in the open but also entrenched.
2. The depth of the lethal zone is very small in connection with which minor deflection of burst for range seriously affect the degree of effectiveness against shallow targets.
3. Effectiveness is to a very great extent dependent on the height of burst.
4. Dispersion both for range for height is considerable.

Taking into account the characteristics of the air burst shell, the conclusion may be drawn that it may be successfully employed against live targets disposed over a large area, when the conditions of the ground preclude or limit the employment of ordinary HE shell or ricochet.

Such targets are: a) personnel situated in deep folds of the ground or ravines; b) personnel situated on steep reverse slopes; c) landing parties approaching the shore; d) infantry entrenched in depth; e) reserves and columns; f) batteries and convoys.

The employment of air burst shell against small isolated targets, (fire points, individual trenches, small groups of infantry and so on) is not effective and therefore should not be used.

Air burst shell may likewise be used for the solution of the following secondary tasks: a) target indication; b) for establishing andchecking the pattern when observing directly from the gun position; c) checking direction when commencing firing and switching; d) bringing bursts within the observable area when firing over broken country; e) for the plotting of bursts on to the artillery board; f) creating a sound reference point, determinging the systematic error and ranging with a stop watch.

40. <u>Correction for height</u>.

In the matter of height air burst is divided into the following categories: 1) non bracketting air bursts (B) which occur at a height which places the burst cloud above the target; such bursts cannot be an observation for range. 2) Bracketting air bursts, or low bursts (H) which occur at a height which places the burst cloud either completely [illegible] partially below the upper limit of the target; such bursts can [illegible]
151. servation for range. Taking into account the considerable size [illegible] burst cloud and also the fact that at the moment of burst the [illegible] slightly, the upper limit of a low air burst is laid down as [illegible] metres. 3) Pecks (K) - bursts which occur on impact; such [illegible] give observation for range.

Fig 64. Influence of correction for elevation on the height of the mean point of burst and mean range.

4) Bursts which occur below the target (Hu) that is below the target horizon; such bursts may occur in broken country; likewise they may give observation for range.

The table setting of the fuze is calculated on the basis of [illegible] the mean point of burst on the gun horizon and when the angle of [illegible] is correctly corrected, on the target horizon. But as a result of the influence of various factors affecting the speed of burning of the [illegible] ing element, a discrepancy creeps in between the respective [illegible] the sights and the fuze. In addition the preparation of initial [illegible] is always accompanied by error, amongst others errors in determining [illegible] angle of sight. For these reasons the actual of the mean point [illegible] usually differs from the one calculated and because of this it [illegible] ary to introduce corrections for height of burst

The fact that the settings for the sights and the fyze do [illegible] and the influence of this fact should be taken into account by [illegible] the fuze and the influence of the errors in determining the angle [illegible] by correcting elevation. However, in practice it is found impossible to determing the degfee of influence of each of the separate causes [illegible] sequently corrections are introduced either for elevation or for the [illegible] Let us examine how the position of the mean point of burst is altered [illegible] each of these corrections.

Altering elevation we thereby alter the position of the mean trajectory If with such an elevation setting (30-00) the position of the mean point of burst was point P1 (fig 64) then by increasing the elevation the range of burst in practice should remain constant as the setting of the fuze has not been altered and consequently the time of flight of the shell up to the moment of burst is also unaltered. The mean point of burst should be displaced more or less vertically to point P2 - to an extent corresponding to the alteration in elevation (up when elevation is increased, down when elevation is decreased). . The range of fall of the shell (if
152 they had not burst in the air) must of course alter as the position of the mean trajectory alters.

In altering the setting of the fuze the position of the mean trajectory remains the same (fig 65) and the mean point of burst is displaced along the trajectory from position P1 to position P2 when the setting of the fuze is reduced, and from position P2 to position P1 when the setting of the fuze is increased. As may be seen from the figure the height and range of burst are also altered. The range of fall of shell remains constant as the position of the mean trajectory is unaltered.

Fig 65. The influence of correction to the fuze on height and on range of the mean point of burst.

Comparing the two methods of introducing corrections for mean point of burst it is possible to indicate the advantages of correcting the elevation: 1) it is easier to determine the correction to be made to the elevation than the correction to be made to the fuze. The height of burst is calculated in divisions of the dial sight which are equal to the divisions of the range sight. The correction may be determined withou any special calculations, but merely by comparing the mean height obtai ed with the height required for ranging.

When introducing corrections for the fuze it is necessary to find ou from the tables the extent of the alteration of the height of burst in relation to the alteration of the setting of the fuze by one division (differing for varying ranges and charges), convert metres into divisio of the dial sight and then only determine the extent of the correction.

2) When correcting by means of elevation the correct relationship between the range sight and the fuze is maintained. One is spared the necessity for remembering the discrepancy introduced when correcting by means of the fuze and of maintaining this discrepancy with each alterati for range. Consequently the liklihood of giving wrong orders is red- uced. 3) In the event of displacement being present the correction by means of the range sight does not take the bursts off the line of obser- vation in the way that this occurs when correcting by means of the fuze. In the event of an individual gun firing systematically inaccurately for height a correction by means of an alteration for range is the only correct method correcting the settings of this gun. Causes giving rise to such systematic inaccurate firing for height by individual guns may be as follows: a) inacurate checking of sights, in particular the range sight, b) a big difference in the gun horizons in the gun position.

153. Both these causes give rise to displacement of the mean trajectory. Consequently to eliminate this it is necessary to alter the angle of elevation, that is to introduce a correction to the range sight.

41. Ranging by means of air burst shell.

Firing with air burst shell is conducted as a rule with the greatest charge as by this means the least possible dispersion of bursts for height is obtained.

In the case of low altitude air bursts in addition to ranging for lin and range it is also necessary to range for mean height of burst.

The object for ranging for the mean height of burst is to discover th settings for the range sight and the fuze which give the greatest number of bursts at the required height for ranging and for firing for effect.

To carry out ranging it is necessary to have observation for range. Such observation is only obtained by means of bracketting bursts, that is "pecks" and low bursts, the number of these being depending on the heigh of the mean point of burst. In order to determine the height of burst which would ensure that ranging for range could be carried out with the least possible expenditure of ammunition and time, it is necessary to calculate the percentage of bracketting bursts at various ranges and with varying heights of the mean point of burst.

If the mean point of burst lies considerably below the target horizon (more than 4BpB) then it is evident that in the absence of an obstacle (the earth's surface) the whole ellipsoid of the bursts must be below the target horizon.

In the event of an obstacle being present, with the mean point of bursts being in such a position all bursts will be "Pecks" that is to say ground bursts, and in fact bracketting bursts. It would appear that this ensures the carrying out of ranging with a minimum expenditure of ammunition. However, it must be remembered that ranging must be carried out not only for line and range but also for the height of burst. Con- sequently, under these conditions, after carrying out ranging for range one should switch over to ranging for height of burst and in the end a very considerable number of rounds and amount of time will be required. For this reason ranging must be carried out at such a height which would give a sufficient number of bracketting rounds (for obtaining observation for range) and at the same time would enable one to judge the height of the mean point of burst.

The calculation of the pprobability of obtaining "pecks" and low burst is the same as the calculation of the probability of hitting the strip of infinite length. To carry out this calculation, it is necessary to know the value BpB, the height of the mean point of burst hep, and the upper limit of the low bursts.

Example. To calculate the probability of obtaining low bursts and pecks when firing a 122 mm how M 1938 on first charge under the following con- ditions: Range 5,000 m; height of mean point of burst hep 2 m and the limit of low bursts 1 = 6 m. (fig 66).

154. In the range tables for range of 5,000 metres we find that BpB = 10 m. The probability of obtaining a low burst will be found as the probability of obtaining a burst within a strip bounded by the earth and the upper limit of low bursts. Width of strip 1 = 6 m = 0,6 BpB.

Boundary of low bursts.

Fig 66. Calculation of the probability of obtaining low bursts and pecks (see example and table 39).

The mean point of burst lies within this strip at a distance of two metres = 0,2BpB from the lower limit and four metres = 0,4BpB from the upper limit of the strip.

The probability of obtaining low air bursts will be found as follows

$$p_H = \frac{1}{2}\,\Phi(0,2) + \frac{1}{2}\,\Phi(0,4) = \frac{0,107 + 0,213}{2} = 0,16$$

Probability of a peck is found like the probability of obtaining a burst lower than the ground horizon. Therefore

$$p_k = 0,5 - \frac{1}{2}\,\Phi(0,2) = 0,5 - \frac{0,107}{2} = 0,446.$$

The results of analogous calculations of probability of obtaining low bursts and ground bursts firing a 122 mm howitzer M 1938, using charge one are in the table below, table 39 (see page 155).

The data given in table 39 shows that with a decrease in height of the mean point of burst from plus six metres to minus two metres the probability of obtaining low bursts alters but slightly whereas the probability of obtaining ground bursts increases and concomitantly the probability of obtaining bracketting bursts increases. The height of the mean point of burst lying between the limits of zero and minus two metres ensures that a sufficient number of bracketting bursts are obtained (from 60 to 84% according to range) and at the same time allows one to judge the height of the mean point of burst by the inter relationship of the air and ground bursts. For this reason ranging with an air burst shell is most advantageously carried out with the height of the mean point of burst lying close to zero. The percentage of ground bursts should be approximately fifty.

Consequently if the angle of sight is measured sufficiently accurately and a check made of the degree of coordination between the range sight and the fuze from previous firing, then the first rounds fired on a fresh target must be fired with the range sight set to correspond [illegible] the measured angle of sight and with the table setting of the [illegible] calculated at obtaining a mean point of burst on the target horizon.

155. Table 39

Range in m	Category of bursts	Probability of bracketting bursts in % at height of mean point of burst over target- -2m	0	+2m	+4m	[illegible]
3,000	Low	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	ground bursts	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Bracketting.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

If fire is opened from a given position in the first instance using air burst shell amd the angle of sight is not sufficiently accurately determined, then the initial rounds must be fired with such settings for elevation and fuze, which allow for the determining of the height of the mean point of burst of the initial round and on this basis introducing the necessary corrections. This may be done sufficiently accurately and readily in a case where air-bursts are obtained with the initial rounds. The height of the mean point of burst is obtained by [illegible] idual estimation of the height of each burst.

If on firing the initial rounds only ground bursts are obtained the conclusion must be reached that the mean point of burst is situated below the horizon. As to the mean point's distance from the horizon a number of suppositions may be made (hypotheses), each one [illegible] own probability.

To obtain all air bursts when firing the initial rounds [illegible] point of burst must be above the horizon of the target by [illegible] table 40 below, are given the values of 4BpB expressed in [illegible] elevation for the various charges and ranges.

In table 40 it may be seen that to obtain all air bursts [illegible] for elevation must be increased in the mean by ten divisions [illegible] to fourteen). Taking into account the degree to which [illegible] broken and the errors in determining the angle of sight [illegible]

156 rule may be established.

Range in m	Values of 4BpB in divisions [illegible]					
	122 mm how M 1938			152 mm how [illegible]		
Charges	Full	first	second	Full	first	[illegible]

When employing air burst shell the first group of rounds should be fired with the elevation increased by from ten to twenty divisions over the calculated amount and with the fuze set on the setting indicated by the tables.

On obtaining the bursts the height and the lateral deviation of each burst from the target is measured in divisions of the dial sight and th height of the mean point of burst is calculated by the use of the formu

$$h_{cp} = \frac{h1 + h2 + h3 + h4}{4}$$

[illegible] h1, h2, h3 and h4 are the measured heights of bursts from the [illegible] horizon.

After this ranging for range begins and if necessary the pattern of bursts is corrected, corrections to the dial sight are introduced and the height of bursts is lowered to the target horizon by lowering the elevation. The correction for elevation is equal to the measured mean height of bursts multiplied by the range coefficient. Ranging for range is carfied out by means of troop fire according to the usual rules applicable to fire for ground bursts. In view of the fact that fire by means of air burst shell is usually conducted against deep targets, ranging may be concluded after obtaining a four division confirmed bracke

Bearing in mind that the most advantageous interval when using air burst shell equals zero one switches over to firing for effect at the centre point of the last bracket or on a setting on which the confirmed covering group was obtained.

When going over to fire for effect the height of the mean point of burst is altered to the most advantageous one: twelve metres when firin [illegible] 122 mm howitzer and fifteen metres when firing a 152 mm howitzer. An [illegible] for the height of the mean point of burst may be carried out [illegible] elevation or by altering the fuze setting. In selecting [illegible] for carrying out corrections (elevation or fuze) it is necess [illegible] in mind that when correcting by means of the fuze the range [illegible] alters.

157. [illegible] When the bracket is obtained the number of ground bursts soes not exceed the number of half of the bursts, then the mean point of burst is either on the ground horizon (when one half are ground bursts) or else above the horizon (when air bursts predominate). In this case as already seen in section forty the range of the mean point of burst does not alte when elevation is altered and consequently corrections must be introduced to the elevation by the amount of the difference between the obtained mean point of burst and that required for firing for effect.

If the bracket is obtained on ground bursts, then the mean point of burst when no obstacle exists must be below ground horizon (fig 67 - point C).

Fig 67. Alteration to the height and range of the mean point of burst when correcting the height of burst by means of elevation.

When correcting elevation the position of the mean trajectory will change in connection with which the mean point of burst will move to a point P and as may be seen from the figure the ranged for range of bursts will alter: the bursts were at point K and after correcting by means of elevation the bursts will be grouped close to point P.

Therefore when the bracket is obtained on ground bursts the correction to the height of the mean point of burst is introduced by meens of the fuze. One division on the fuze alters the height of the mean point of burst at all ranges by approximately 2BpB. As the obtaining of ground bursts only indicates that the mean point of burst is below the horizon by 4BpB or more, the correction to the fuze is taken to be equal to two divisions.

If the bracket has been obtained with a predominance of ground bursts this indicates that the mean point of burst is below the horizon by on th average one to two BpB (depending on the proportion of ground to air burst In this case the correction for the fuze is taken as being equal to one division.

Fire for effect is conducted by means of jumps of one to two ΔX with a corresponding alteration to the fuze setting within the limits of the bracket obtained. Order of fire - gun fire with two to four rounds on each setting.

42. Employment of air burst shell against targets on reverse slopes.

When a target is situated on a reverse slope it may be hit by a shell with percussion fuze only when the angle of slope is less than angle of descent.

When the angle of slope is ~~xxxx~~ greater than the angle of descent then as is
158. evident in fig 68 the bursts of shell equipped with percussion fuzes will either be on the crest (point P1) or will pass over the target (point P2).

Under these circumstances, in order to hit the target it is necessa[illegible] to employ air burst shell.

One first of all ranges on the crest masking the target. Ranging o[illegible] to the crest may be conducted by means of either shell with percussion fuzes or by air burst shell. In both cases fire continues until a two division confirmed bracket has been obtained. If ranging has been carried out with percussion fuzes, then before going over to fire for effect a controlled series with air burst shell is given with the range sight set to correspond with the nearest edge of the bracket with the fuze set according to the tables

Fig 68. Firing with percussion fuze shell on a target situated on the reverse slope. Angle of slope is greater than the angle of descent.

When only ground bursts are obtained the setting of the fuze is reduced by two divisions and one more controlled series is fired. When only air bursts are obtained from the controlled series, the fuze settin[illegible] is increased by from one to two divisions, depending on the height of burst.

Ranging for height of burst with fixed settings for elevation and angle of sight, introducing corrections only by means of the fuze continues until both ground bursts and air bursts are obtained in one serie[illegible] Fire for effect then commences on the furthest edge of the bracket. Fir[illegible] for effect is conducted employing from three to five fuze settings depending on the length of slope; altering the setting of the fuze by one division at a time, without altering the setting of elevation and angle of sight. The bursts as is shown in figure 69, will move with the alterations to the fuze along the line of the trajectory and will strike targets situated on the reverse slope.

Fig 69. Fire with air burst shell against personnel situated on a reverse slope.

45. Fire with air burst shell against a captive ballon (aerostat)

Fire for the destruction of a captive balloon (aeros[illegible] by means of air burst shell. The shells' high explosive [illegible] ation action is exploited. As the probability of obtain[illegible] of whether the burst is plus or minus when firing against [illegible] oon is very small, ranging and fire for effect must be [illegible]
159. coordinated observation. If the balloon is visible from [illegible] ition, it is profitable to employ a combination of fire over [illegible] with ranging on measured deflections. When using this com[illegible] the direction and height of burst are corrected on observ[illegible] gun position, and the range of burst according to the res[illegible] references from the points of coordinated observation. [illegible] is not visible from the gun position, then corrections for [illegible] directions (height, range and line) are introduced on a basi[illegible] references on the bursts made from the points of coordinate[illegible]

Let us consider first of all a case when the balloon is [illegible] the gun position. The balloon's coordinates in a horizont[illegible] determined by means of simultaneous cross references being [illegible] its basket from the points of coordinated observation, [illegible] plotting the projection of the balloon on the artillery bo[illegible] gun position the angle of sight of the balloon is measured [illegible] the reflector, with the elevation at 30-00. The range mea[illegible] artillery board from the point of the pivot gun to the proj[illegible] balloon is utilised to determine the settings for the range [illegible] the fuze and the angle of sight measured from the gun posit[illegible] ermining the setting of the quadrant elevation. As the ang[illegible] when firing at a balloon is always very great then one mus[illegible] corrections to the angle of elevation and as far as possible [illegible] tions for ballistic and meteorological conditions.

The pivot gun is laid on the balloon over open sights and [illegible] are recorded. In order to achieve at least some element of [illegible] ranging is conducted not on the balloon itself but some five [illegible] one thousand metres to one side of it. To this end having [illegible] setting of the dial sight by 1-00, and laying the gun on the [illegible] [illegible] r to six rounds are fired by the pivot gun on the calcula[illegible] [illegible] elevation, range and fuze. After each round, the gun is [illegible] relaid and at the moment when the burst appears, it is fixed [illegible] the dial sight and reflector. (Prismatic compass ?). The [illegible] obtained are noted down.

Each burst is plotted by the points of coordinated observation and having calculated the mean point of burst it is plotted on the artillery board. From the artillery board, the range from the pivot gun to the projection of the mean point of burst is determined. Before going over to fire for effect cross bearings from the points of coordinated observation are once again taken onto the balloon and the range determined from the gun to the projection of the balloon's position.

Fire for effect against a static balloon is conducted over open sights. For all guns, the setting of the dial sight - 30-00 is corrected to the amount of the [redacted] mean setting of the pivot gun based on bursts, the setting of the reflector is taken as being equal to the mean setting of the gun obtained from bursts and the settings of the dial sight and fuze are corrected in accordance with the difference in range between the range to the balloon and the range to the mean point of burst. The settings on the dial sight and reflector are determined by means of pivot gun ranging with the gun laid on the balloon if it is stationary. If, however, the balloon is manoeuvring then the settings of the dial sight and reflector are corrected to anticipate the movement of the balloon during the time of the flight of the shell.

In order to determine the amount of laying off necessary in the horizontal and vertical planes, the cross hairs of the director are laid on to the balloon, this moment being noted and from the scale on the instrument, the movement of the balloon is measured over the period equal to half (or one third) of the time of flight of the shell. On the basis of this, corrections are introduced to the settings of the dial sight and reflector equal to double (or treble) the values of the angular displacement of the balloon in the horizontal and vertical planes. Because of the const uction of the dial sight and the reflector corrections to the dial sight are made in the direction of movement of the balloon and corrections to the reflector are made in the opposite direction.

Fire for effect is conducted on three settings of the range sight: the calculated, increased by 2 X (100 metres) and decreased by 2 X (100 metres). When altering the setting of the range sight the setting of the fuze is correspondingly altered. Two rounds gunfire are given on each setting. Corrections are introduced in the course of firing for effect on the basis of observations obtained from the gun position and from points of coordinated observation. At the gun position, observation is conducted for line and height. If the bursts of the first series are displaced to one side, the senior officer at the troop position stops fire, introduces corrections to the dial sight corresponding to the lateral displacement of burst from the balloon and repeats the series. Corrections to the reflector are introduced if the bursts of the first series are all either above or below the balloon and if this displacement of the mean point of burst for height exceeds three divisions of the dial sight.

The estimate of the range of burst is arrived at from observations made from the points of coordinated observation. If the bursts from each of the points are observed to be on each side of the line of observation, this indicates correct setting of the range sight and fuze. If the bursts in a series were observed by each point to be to one side of the line of observation, for example to the left point - to the right and for the right point to the left, this indicates that an error has crept in to the settings of the range sight and fuze. In this case the setting of the range sight is altered in the opposite direction to the direction of displacement, the correction made being of four divisions with a corresponding correction to the fuze, the series is then repeated.

If the balloon is not visible from the gun position, ranging and fire for effect are conducted from observations made by the points of coordinated observation. In this case by means of cross references from the observations one determines not only the balloon's coordinates in the horizontal plane but also the balloon's height. Having plotted the balloon's projection on the artillery board, the directional angle (director) is determined as well as the range from the pivot gun. The setting for elevation is calculated in accordance with the measured height of the balloon above the gun (angle of sight) introducing a correction to the tangent elevation by the angle of sight to the target. To establish a reference point, the setting of the dial sight is altered by 1-00 andusing the calculated settings for elevation, range and fuze, a group of from four to six rounds is fired with from 10-15 secs interval

At the points of coordinated observation each burst is plotted for direction and height and on the basis of the mean calculations the height of the mean point of burst is determined as well as the coordinates in the horizontal plane. The projection of the mean point of bur is plotted on the artillery board. The coordinates and the altitude of the balloon are determined for the second time. Having measured on the artillery board the angle between the directions from the pivot gun to the mean point of burst and to the balloon, the correction for the dial sight is determined. Correction for elevation is obtained by determining the height of the mean point of burst above the balloon, the correction for the range sight and fuze are determined through the difference in range between the balloon and the mean point of burst. Fire for effect is conducted with a pattern of fire for effective neutraliaation and as in firing over open sights on three settings of the range sight and fuze.

Comparing the two methods described it is possible to indicate the advantages and disadvantages of each.

1) Firing over open sights with a well drilled gun crew it is possible to attain a higher level of accuracy. This is explained by the fact that in firing for effect direct laying is carried out and consequently the movement of the balloon both for direction and height is automatically taken into account.

2) Firing over open sights even with a well drilled gun crew requires a considerable expenditure of time over ranging. This is explained by the fact that after each round the burst must be plotted and after that one must once again plot the point of aim. The time of flight for the typical range fpr this type of shoot will be in the region of from thirty to forty seconds. If one adds to this ten seconds for plotting the burst passing on of calculations and plotting the point of aim we come to the conclusion that rounds may be fired at approximately fifty seconds interval. By the second method however, the rate of fire will be of from ten to fifteen seconds interval. Thus, for the six ranging rounds when firing over open sights one must have from three to four minutes extra time which might be employed by the enemy for the purpose of lowering or moving the balloon.

Simultaneously with firing at the balloon it is recommended that another troop should engage the winch. Firing at a winch is normally carried out with shell with fuze set for fragmentation action. The positionof the winch in relation to the balloon may be determined by finding out the position of the winch of one's own balloons. This information may be obtained from the air force unit, who knowing the height of the enemy balloon determines the direction and the length of the horizontal projection of the line connecting the enemy balloon to the enemy winch.

Having obtained this information the observer plots on the artillery board first the balloon and then the winch. The initial settings for
162. firing at a winch are determined as a rule through calculating the swith from an aiming point already ranged upon. Fire for effect is carried out by engaging an area in depth of from three to four percent of range and of from ten to fifteen divisions of the dial sight in width. Firing on the winch begins simultaneously with the firing at the balloon and continues for the same period of time.

44. The Action of Shrapnel.

Shrapnel has a case shotaction. Case shot action is the term given to the action created bynfragments (shot, rods and filling) thrown out of the shell by the force of the exploding charge.

The characteristics of shrapnel as a shell are, a) speed given to the shot by the exploding charge; b) penetrating qualities of the shot at the various distances; c) the angle of spread of shot; d) number of targets struck. The last is the measure of shrapnel action.

Fig 70. A graph showing the dependence of the number of lethal shot of a 76 mm shrapnel shell on the extent of the interval of burst

With the object of studying these actions, individual shrapnel rounds were exploded: a) the shell stationary which bursts on the ground b) in motion, when the shell fired from a gun burst in the air.

Speed given to the shot by the exploding charge! Let us picture the shrapnel shell before it explodes. Evidently in this position each each individual bullet within the shell will have the same speed and because of the spinning of the shell the same spin speed as the whole shell. At the moment of burst, one must add to the speed of flight of the bullet the additional speed given by the bursting charge.

As a result of trials it has been established that on the average the additional speed given by the bursting charge is equal to v.charge = 77 m/sec, provided that the shell remains intact. In the event of the shell bursting, the additional speed of the bullets is reduced by approximately ten per cent.

The same trials showed that a shrapnel shell both at the time of burst and at rest gives a cone of spread of bullets as each bullet, generally speaking, possesses additional speed not only along the line of the axis of the shell but also sideways, the extent depending on the type of bullet. The greatest lateral speed has been determined by trial and was found to be equal to v_6 = 27 m/sec.

'Penetrating qualities of bullets'. Lethal bullets are those capable of putting a man hors de combat. In practice it is taken that lethal bullets are those that/penetrate a 2.5 cm deal plank [illegible] pierce/ of all the bullets that lodge in the plank.

By trial it has been established that there is a [illegible] ship between the interval and the number of lethal [illegible]

163.

From the figure it is seen that as the interval increases the percentage of lethal bullets decreases, at the same time [illegible] decline begins from the distance of 160-200 metres.

As may be seen from fig 70, the practical lethal [illegible] rounds in the air (that is an interval which gives a lethal [illegible] fifty percent)/ for 76 mm shrapnel is 280 metres.

'The angle of spread of bullets'. At the moment of burst of the shrapnel shell its bullets possess the following speeds:
a) vehicular speed equal in extent and identical in direction to the speed of the shell at the moment of burst. (vo);
b) additional speed given by the bursting charge and directed along the axis of the shell (v.charge);

Remaining velocity of the bullet

Fig 71. Remaining velocity of shrapnel bullet at moment [illegible]
vc: speed at the moment of burst; v.charge: [illegible]
by the bursting charge along the normal to the [illegible]
vBp: speed from the spin of the shell.

c) additional speed given by the bursting charge and [illegible] towards the sides of the shell (v_6);
d) speed given by the spin of the shell around its axis [illegible] being towards the sides of the shell (v_{BP}).

The directions and the extent of these speeds are [illegible]

If we add together all these speeds according to the [illegible] of additions of vectors we will see that under the influence of these speeds the flight of the bullet will have the direction [illegible]

The angle of spread of bullets is determined by the [illegible] the greatest displacement (deflection).

In view of the fact that for this type of gun and shell the [illegible] v.charge and v6 created by the action of the bursting charge do not depend on the range, that is are constant and the spin of the shell is reduced in flight to such an insignificant extent that [illegible] also is considered constant, we may accept that the angle [illegible] depends only on the final speed vc, at the moment of burst [illegible] range. The extent of alteration to the angle of spread [illegible] in range for the 76 mm gun is given in table 41.

Knowing the angle of spread of bullets and the angle of [illegible] shell (the latter being determined from the tables) it is [illegible] determine the downward angle of flight of the lowest bullet [illegible] 72 we see that the angle which interests us, that is [illegible] (from geometry we know that the/external angle in a triangle is equal [illegible] sum of two internal angles).

164.

76 mm divisional gun. Table 41

	Range in metres				
	1,000	2,000	3,000	4,000	[illegible]
Angles of spread of shrapnel bullets.	14°50'	18°00'	20°30'	22°10'	23°30'

On the same basis it is possible to determine the angle of the [illegible] bullet: $\Theta_c = \frac{w}{2} + \beta$ from which $\beta = \Theta_c - \frac{w}{2}$.

Fig 72. Angle of spread of shrapnel bullets.
w = angle of spread of bullets; θ = angle of descent of lower bullet; θ = angle of descent of upper bullet; θ_0 = angle of descent.

In utilizing these formulae one must take into account that in constructing them we took the bullet trajectories as being straight lines, whereas in actual fact (particularly the upper bullets) the trajectories with small angles of descent are curved to a considerable degree and the angle of descent calculated by the formula is considerably less than the true one. One can, therefore, only employ these formulae for rough calculations and within certain limits of angles of descent of the shell.

The depth of the area struck by the bullets depends on: 1) the height of burst; 2) range, as with distance the angle of descent of the shell and the dispersion of bullets alters. At medium ranges with height of burst being 2Δy the depth of the area affected employing 76 mm divisional gun equals 150 to 200 metres.

The width of the affected area alters likewise with the alteration in range and mainly with the height of burst. At medium ranges this width for a 76 mm divisional gun equals 12, 24 and 36 metres corresponding to heights Δy, 2Δy and 3Δy, that is in the mean, whis width is equal to 20 to 25 metres.

Knowing the extent of the lethal interval and assuming the areas of the targets to be of different sizes as well as the interval on the ground varying, it is possible to calculate the number of targets which will be hit under these conditions.

As a result of these calculations confirmed by trial, it is established that 'for a 76 mm divisional gun the most advantageous interval on the ground depends little on range and for all practical purposes may be taken to be 55 metres for all ranges.

If all the shrapnel shells were to burst at one point, then the conditions for most effective neutralization for a group of rounds would be the same as for a single round, that is the most advantageous interval for a group of rounds from a 76 mm gun would be equal to 55 metres or approximately ΔX. However, the presence of dispersion of bursts introduces material alterations. In the event of the interval of the mean point of burst being equal to 1Δy a considerable/proportion/of the bursts because of dispersion would take place after the shell had hit the ground, that is ground bursts would be obtained; some proportion of the bursts would take place behind (beyond) the target; both these categories do not produce any effect. For this reason for a group of bursts the 55 metre interval of bursts is not the most advantageous one. From calculations and by trial it has been established that/the most advantageous interval for a group of shrapnel shell of 76 mm gun equals 2ΔX, that is 100 metres.

165. The relationship between the effectiveness of neturalization and the interval of the mean point of burst has also been established. This relationship in respect of the 76 mm gun with the mean trajectory passing through the target is given in the form of a graph in figure 73. Points C1, C2, C3 etc., show the mean points of burst along the mean trajectory with the intervals 1ΔX, 2ΔX, 3ΔX and so on.

The ordinates of the curve ABD give the relative extent of neutralisation depending on the interval of bursts. Neutralization with the interval being 2ΔX is taken as the unit. Studying fig 73 we see that the greatest neutralization with the trajectory passing through the target is achieved when the interval of the mean point of burst equals 2ΔX and consequently, its height equals 2Δy. This interval as already indicated is the most advantageous one and the height corresponding to it - 'is the most advantageous height'.

In the event of the interval of the mean point of burst deviating towards the less or greater side in relation to the most advantageous one, the effectiveness of neutralization as may be seen from the figure, decreases. At the same time deviation within the limits of 1ΔX lessens the effectiveness to a comparatively insignificant degree (not more than one-sixth of the greatest). Consequently, errors in fuze setting to the extent of one division in one or the other direction are allowable and the mean height of burst may lie within the limits of from one to threeΔy.

Fig 73. The influence of the interval of burst on the neutralization of narrow targets. Cp mp. = mean trajectory.

The neutralization of the target depends not only on the height of the mean point of burst but also on the position of the mean trajectory in relation to the target.

Let us assume that the height of the mean point of burst remains constant, equal to the most advantageous one and the mean trajectory moves in relation to the target.

The extent to which neutralization of the target depends on the position of the mean trajectory is given in the form of a graph in fig 7

Points II, III2, II3, II 4, II 5 and II6 indicate the various positions o the target; the distance between two adjoining positions is 1Δ X. The ordinates of the curve KEL give the relative degree of neutralization fo the various positions of the target in relation to the mean trajectory.

A study of this graph allows one to make the following deductions:

1) The greatest neutralization is obtained when the mean trajectory pas -es through the target (this is taken as being unity).
2) In the case of the trajectory falling short by 2Δ X that is 100 metr (position of the target at II5) or the trajectory overshooting the target by 1Δ X, that is 50 metres (target being at II2) neutralizatio decreses by the same amount - decrease on minus half that of plus

Consequently, with a constant height of the mean point of burst, errors in setting the range sight for minus (minus mean trajectory) do not effect neutralization to the same extent as errors for plus (plus mean trajectory).

3) If we take a strip 150 metres in depth situated assymetrically to th mean trajectory (100 metres forward and 50 metres to the rear), then at any point within this strip neutralization will not be less than half of the greatest neutralization that is, neutralization attained when the mean trajectory passes through the target. This strip 3Δ X in depth (150 metres) is called the effective beafen zone.

Summarizing all that has been said relating to the action of shrapn one can reach conclusions concerning the positive and negative [illegible] of shrapnel shooting. To the positive ones belong:

a) good case shot action against personnel in the open;
b) good depth of neutralization;
c) comparatively little effect on neutralization due to errors in [illegible] and fuze setting.

166. The weekest point in shrapnel shooting to a large extent [illegible] out the positive qualities is the fact that shrapnel shooting is [illegible] effective against personnel in the open and has no effect against [illegible] nel under cover in trenches, ditches or behind any form of [illegible] shield, etc. Shrpnel shooting cannot be employed for the [illegible] field works various forms of obstacles and for the destruction [illegible] and armoured vehicles.

Effective beaten zone.

Fig 74. Influence of the distance of the mean trajectory from [illegible] target on the neutralization of a narrow target.

Thus under conditions of present day warfare shrapnel shooting may be given effective employment in very rare cases, namely against troops in the open. But this task may be effectively fulfilled with other [illegible] of shell - shell with fuze set for fragmentation action or fuze with delayed action, intended to produce ricochets. A shell, as is known, is universal ammunition which can fulfil not only these but many other tasks. In addition it is also necessary to point out the great [illegible] manufacture of shrapnel shell and the difficulty in ranging requiring considerable skill.

Consequently, shrapnel shell, once considered to be on of the [illegible] shells, at the present time has lost value and is no longer in production

45. Shooting with Incendiary shell.

Incendiary shells are equipped with a distance fuze possessing [illegible] action, but instead of bullets, they are filled with incendiary cartridges, manufactured out of special thermal compound. The number of cartridges varies and depends on the calibre of the gun. At the moment of burst, the cartridges ignite, develop a very high temperature, reaching [illegible],000 degrees and on hitting the target ignite it.

Incendiary shells are intended for:

a) starting fires within inhabited localities, setting fire to wooden buil-[illegible], bridges, observation towers and other works;

b) for starting forest and prairie fires, setting fire to ripe corn etc.
167. c) for use against fuel and ammunition dumps, vehicle concentration points and railway stations.

Ranging with incendiary shells is carried out with one gun until an eight division bracket is obtained. Subsequent ranging is carried out with a troop until a two division confirmed bracket is obtained in the case of small targets and until a four division or an eight division is obtained in the case of deep targets. Settings for the range sight and fuze are determined with the aid of special Tables for shooting with incendiary shells.

Fire for effect against small targets (isolated buildings etc.,) is initiated with the range sight set to sorrespond with the centre of the bracket and subsequently corrections are introduced on the basis of observations of the fall of indendiary segments.

Fire for effect against deep targets is carried out on several settings of the range sight and fuze within the limits of the bracket obtained..

The pattern on the ground should correspond to the width of the target.

The best height for the mean point of burst is two to three divisions of the dial sight when firing on buildings and five to eight divisions of the dial sight when firing on woods, bushes, dried grass etc.

If firing is being carried out against buildings which are likely to contain inflammable material to a greater degree than is present outside the building, the fuze should be set to burst on impact.

46. Firing smoke shell.

Smoke shell is equipped with an instantaneous fuze and filled with a special type of smoke producing compound.

Fragmentation and HE action of the shell is negligible.

The basic tasks of smoke shell are:

a) blinding (smoking) of OP's and enemy fire points;
b) screening by smoke of large areas by laying down smoke screens with the object of hiding the activity of own troops and preventing the enemy from observing his fire.

In addition, smoke shells may fulfill such tasks as: target indication by bursts from an already ranged troop, ranging under conditions when observation of HE fragmentation shell bursts is difficult, ranging with the aid of an aeroplane or a balloon.

The effectiveness of shooting with smoke shell and expenditure of ammunition for fulfilling a fire task, depend to a large degree on the type of ground and mainly on meteorological conditions.

Favourable conditions for firing smoke shell are:

a) Low wind speed - not more than five metres per second;
b) direction of wind parallel to the front of the smoke screen;
c) absence of upward air currents;
168. d) great air humidity;
e) firm ground in the target area.

Ranging is carried out either with smoke shell or to preserve the element of surprise with HE fragmentation shell.

Ranging with smoke shell is normally begun with rounds fired beyond the target in order that the smoke of these rounds should not hamper observation.

In view of the fact that when firing smoke shell, the smoke screen envelops a considerable area, great accuracy in ranging is not necessary; for this reason when laying a smoke screen around isolated targets, ranging is carried out until a four division bracket is obtained, whereas in laying down larger smoke screens, an eight division bracket is sufficient. It is sufficient if one accurate observation for range is obtained at each extremity of the bracket. When ranging on measured deflections, a group of from two to four rounds is given and on the basis of cross references from the various points of coordinated observation, corrections are determined for the settings to be employed in laying down smoke.

Two or three controlled rounds are put down in the centre of the bracket obtained when ranging by observing bursts or on settings determined on the basis of cross references when ranging on measured deflection and observing the movement of the smoke cloud, corrections for direction and range are introduced, after which fire for effect is carried out with smoke.

Withal one must bear in mind, that one does not range on the targe itself but on the part of the target area where the shells must burst, the part of the area being chosen with the aim of getting the smoke cloud to drift across the target. In the event of the wind blowing towards the enemy, the mean point of burst must be from fifty to one hundred metres in front of the target - for isolated targets - and from one hundred to four hundred metres - for laying down smoke screens; in the event of the wind blowing directly away from the enemy, the mean point of burst must be roughly on the forward edge of the target; in the case of a wind blowing parallel to or obliquely across the target to be screened the mean point of burst must be carried to one side fift to one hundred metres in the direction from the which the wind is blowing, the distance depending on wind velocity.

A four gun troop under favourable meteorological conditions can effectively screen the following frontage: with a frontal wind one hundred to one hundred and fifty metres, and with a flank wind, three hundred to five hundred metres.

Depending on the required width of front to be screened and on the direction of the wind a troop, a battery or a number of batteries may be employed for laying down a smoke screen.

In order to screen an isolated object (OP, fire point etc.,) a troop is normally employed; with a flanking wind and under favourable meteorological conditions, the task of screening an isolated target may be carried out by a section.In the case of flanking fire for screening an isolated target a concentrated pattern is laid down irrespective of the direction of wind, in the case of frontal fire and frontal wind a
169. parrallel is employed, with a flanking wind, a concentrated pattern.

To produce a dense cloud rapid fire is given, three to six rounds per gun, depending on calibre. Subsequently, the required density is maintained by means of methodic fire at the rate of from five to twenty seconds interval.

If thinning of the cloud is observed, the rapid fire is repeated. By trial it has been established that to lay down and maintain a smoke screen for fifteen seconds covering a front of one kilometre with wind velocity of five metres per second, the following number of rounds is required:

Calibre in mm	Direction of the wind. Toward or from the enemy	Flanking
76	1,000	500
122	300	150

With wind speeds of 6 to 7 metres per second the expenditure of rounds is increased by fifty to sixty per cent. For the screening of isolated targets (OP, fire points etc.,) for a period of fifteen minutes the following number of rounds:

Calibre in mm	Frontal wind: Up to 5 m/sec	Frontal wind: +5m/sec	Flanking wind: up to 2m/sec	Flanking wind: 3 - 5 m/sec	Flanking wind: 6 - 7 m/sec	Flanking wind: more than 7 m/ sec.
76	120	200	50	80	180	180
122	40	70	20	30	40	80

With a snow covering of more than twenty centimetres, the expenditure of shell in all cases will be increased by fifty to eighty percent

47. Firing with illuminating shell.

Illuminating shell have a time fuze and are equipped with illuminating segments secured to a parachute. When the shell bursts, the segments ignite and slowly descend on the opened parachute, slowly burning and brightly illuminating the area. The burst of the illuminating shell in the air should take place at such a height that the largest possible area is brightly illuminated and that the duration of illumination is
170 the greatest possible. If the shell bursts very high, then the area illuminated will be considerable, but the degree of illumination will be insufficient. If the shell bursts at a low altitude, then the illumination will be sufficiently bright, but the area inconsiderable, and the segments will fall to the ground incompletely burned, as a result of which the duration of illumination will be curtailed. As shown by trial the best results are achieved when a 122 mm illuminating shell bursts at

a height of four hundred to five hundred metres. Full illumination of ~~the area~~ commences after a period of from three to five seconds following the burst and continues for one minute. The diameter of the circle illuminated is approximately one kilometre.

The best illumination of an object is obtained when the shell bursts vertically above it with the greatest possible angle of descent. For this reason, firing should be conducted with the lowest possible charge compatible with range. Fuze settings that give the best heights are given in the Tables.

An indication of the best heights of burst is the complete burning out of the segments at the moment of their reaching the ground.

If the segments hit the ground before being completely burned out (which considerably reduces observation) or burn themselves out at a considerable height (over fifty metres), then the elevation should be altered in the appropriate direction by ten divisions.

If the correction is found to be insufficient, it is repeated; if it is found to be two great, then an intermediate correction with the reverse sign is introduced.

Continuous illumination of the target is achieved by means of the employment of troop fire with thirty to forty seconds interval.

If the illumination of the area is required for the purpose of ranging by another troop, then the rounds fired by the troop employing illuminating shell are fired on orders of the commander of the ranging troop and timing is synchronized in such a way as to get the shells bursting on the target fifteen to twenty seconds after the burst of the illuminating shell.

If a particularly bright and continuous illumination of an area is required (for reconnaissance or observation) firing is carried out by section or a troop firing ~~rapid~~ gun fire, one round to a gun with thirty to forty seconds interval.

Appendix

Tables of Values of Φ ( )

Probability of obtaining an error within the limits of from 0 to ± .

Editor: Colonel A.N. MARYSHEV.

Technical Editor: G.N. NIKITIN.

Proof Reader: A.N. KLETSKAYA.

Issued to Press 30. 11. 48.